

Mathematicall  
**M A G I C K.**

OR,  
**THE WONDERS**

That may be performed by  
*Mechanicall Geometry.*

In two Books.

C O N C E R N I N G  
Mechanicall } POWERS.  
                  } MOTIONS.

BEING ONE OF  
The most easie, pleasant, usefull,  
(and yet most neglected) part of  
*M A T H E M A T I C K S.*

*Not before treated of in this language*

By *J. W. M. A.*

*Τέχνη κρατῶμεν ὧν φύσει νικώμεθα.*

L O N D O N,

Printed by *M. F.* for *Sa. Gellibrand* at the  
brazen Serpent in *Pauls Church-yard.* 1648.

*John Williams*





TO HIS  
HIGHNESSE  
The Prince Elector  
Palatine.

May it please your Highnesse,



*Should not thus have presented  
my diversions, where I owe my  
study and business, but that  
where all is due, a man may  
not justly withhold any part.*

*This following Discourse was composed  
some years since at my spare hours in the  
University. The Subject of it is mixed  
Mathematicks; which I did the rather at  
such times make choice of, as being for  
the pleasure of it, more proper for recrea-  
tion, and for the facility more sutable to  
my abilities and leisure.*

*I should not Sir, have been ambitious  
of any so Great (I could not of any Better)  
Patronage, had not my relation both en-  
gaged and emboldned me to this Dedic-  
ation.*

*They that know your Highness how  
great an encourager you are, and how able*

## The Epistle.

*a Fudge in all kind of ingenuous arts and literature, must needs acknowledge your prestures and low condition, to be none of the least mischiefs ( amongst those many other ) under which the Common wealth of learning does now suffer.*

*It would in many respects much conduce to the generall advancement of religion and learning, if the reformed Churches in whose cause and defence your family hath so deeply suffered, were but effectually mindfull of their engagements to it. And particularly, if these present unhappy differences of this Nation did not occasion too much forgetfullness of their former zeal and professions for the vindicating of your family, and the restoring of your Highness; the hastning and accomplishment of which, together with the increase of all heavenly blessings upon your Highness, shall be the hearty daily prayer of*

Your Highness

most humble and most devoted

servant and Chaplain,

JOHN WILKINS.

TO  
THE READER.

✻✻✻✻ It is related of *Heracitus*, that when  
✻ I ✻ his Schollars had found him in a  
✻✻✻✻ tradesmans shop, whither they  
were ashamed to enter, He told  
them, *Quod neque tali loco dii*  
*desunt immortales*, that the gods were as well  
conversant in such places as in others; Inti-  
mating that a divine power and wisdom might  
be discerned even in those common arts, which  
are so much despised; And though the ma-  
nual exercise and practise of them be esteemed  
ignoble, yet the study of their generall causes  
and principles, cannot be prejudiciall to  
any other ( though the most sacred ) pro-  
fession.

It hath been my usual custome in the course  
of my other studies, to propose divers Mathe-  
maticall or Philosophicall inquiries, for the  
recreation of my leisure hours, and as I could  
gather satisfaction to compose them into some  
forme and method.

Some of these have been formerly publi-  
shed,

## To the Reader.

shed, and I have now ventured forth this discourse; wherein besides the great *delight and pleasure* (which every rationall Reader must needs find in such notions as carry with them their own evidence and demonstration) there is also much *real benefit* to be learned; particularly for such Gentlemen as employ their estates in those chargeable adventures of Drayning, Mines, Cole-pits, &c. who may from hence learn the chief grounds and nature of Engines, and thereby more easily avoid the delusions of any cheating Imposter: And also for such *common artificers*, as are well skilled in the practise of these arts, who may be much advantaged by the right understanding of their grounds and *Theory*.

*Scho. Mathem. l. 2.*

*Ramus* hath observed, that the reason why *Germany* hath been so eminent for Mechanicall inventions, is because there have been publick Lectures of this kind instituted amongst them, and those not onely in the learned languages, but also in the vulgar tongue, for the capacity of every unlettered ingenious Artificer.

*Agrippa,  
De Vanit.  
Scient. &c.  
42.*

This whole Discourse I call *Mathematicall Magick*, because the art of such Mechanical inventions as are here chiefly insisted upon, hath been formerly so stiled; and in allusion to vulgar opinion, which doth commonly attribute all such strange operations

unto



## To the Reader.

unto the power of Magick ; For which reason the Ancients did name this art *Θαυματοποιική*, or *Mirandorum Effectrix*.

The first book is called *Archimedes*, because he was the chiefest in discovering of Mechanical powers.

The second is styled by the name of *Dædalus*, who is related to be one of the first and most famous amongst the Ancients for his skill in making *Automata*, or self-moving Engines : both these being two of the first Authors that did reduce Mathematicall principles unto Mechanical experiments.

Other discourses of this kind, are for the most part large and voluminous, of great price and hardly gotten ; and besides, there are not any of them ( that I know of ) in our vulgar tongue, for which these Mechanicall arts of all other are most proper. These inconveniences are here in some measure remedied, together with the addition ( if I mistake not ) of divers things very considerable, and not insisted upon by others.

The



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ARCHI-



# ARCHIMEDES,

OR

# MECHANICALL

## Powers.

### *The first Book.*

CHAP. I.

*The excellency of these Arts. Why they were concealed by the Ancients. The Authours that have treated of them.*

ALL those various studies about which the sons of men do busie their endeavours, may be generally comprised under these three kinds:

{ Divine.  
 { Natural.  
 { Artificial.

B

To

Sen. Ep.  
88.

To the first of these, is reducible, not only the *speculation* of Theological truths, but also the *practise* of those virtues, which may advantage our minds, in the enquiry after their proper happiness. And these arts alone may truly be styled liberal *Quæ liberum faciunt hominem, quibus, curæ virtus est*, (saith the divine Stoick) which set a man at liberty from his lusts and passions.

To the second may be referred all that knowledge, which concerns the frame of this great Universe, or the usual course of providence in the government of these created things.

To the last do belong all those inventions, whereby nature is any way quickned or advanced in her defects : These artificial experiments being (as it were) but so many Essays, whereby men do naturally attempt to restore themselves from the first general curse inflicted upon their labours.

This following Discourse, does properly appertain to this latter kind.

Now



Now Art may be said, either to *imitate* nature, as in limning and pictures; or to *help* nature, as in medicine; or to *overcome*, and *advance* nature, as in these Mechanical disciplines, which in this respect are by so much to be preferred before the other, by how much their end and power is more excellent. Nor are they therefore to be esteemed less noble, because more practical, since our best and most divine knowledge is intended for action, and those may justly be counted barren studies, which do not conduce to practise as their proper end.

But so apt are we to condemn every thing which is common, that the ancient Philosophers esteemed it a great part of wisdom, to conceal their learning from vulgar apprehension or use, thereby the better to maintain it, in its due honour and respect. And therefore did they generally veil all their Arts and Sciences, under such mystical expressions, as might excite the peoples wonder

Macrobius  
Sonn.  
Scip. l. 1  
c. 2.

and reverence, fearing least a more easie and familiar discovery, might expose them to contempt. *Sic ipsa mysteria fabularum cuniculis operiuntur, summatibus tantum viris, sapientia interprete, veri arcani consciis; Contenti sint reliqui, ad venerationem, figuris defendentibus à vilitate secretum, faith a Platonick.*

Hence was it, that the ancient Mathematicians did place all their learning in abstracted speculations, refusing to debase the principles of that noble profession unto Mechanical experiments. Infomuch, that those very Authours amongst them, who were most eminent for their inventions of this kind, and were willing by their own practise, to manifest unto the world, those artificial wonders, that might be wrought by these arts, as *Dadalus, Archytas, Archimedes, &c.* were notwithstanding so much infected with this blind superstition, as not to leave any thing in writing, concerning the grounds and manner of these operations.

Quin-

*Quintilian* speaking to this purpose of *Archimedes*, saith thus. *Quamvis tantum tamque singularem Geometriae usum, Archimedes, singularibus exemplis, & admirandis operibus ostenderit, propter quae non humana sed divina scientia laudem sit adeptus, haesit tamen in illa Platonis persuasione, nec ullam Mechanicam literam prodere voluit.*

By which means, posterity hath unhappily lost, not only the benefit of those particular discoveries, but also the proficiency of those arts in general. For when once the learned men did forbid the reducing of them to particular use, and vulgar experiment: others did thereupon refuse these studies themselves, as being but empty and useless speculations. Whence it came to pass that the science of Geometry was so universally neglected, receiving little or no addition for many hundred years together.

Amongst these Ancients, the divine *Plato* is observed to be one of the greatest sticklers for this fond

*Quint. l. 1*  
c. 10.

*Pet. Rsm.*  
*Schol Math.*  
*them l. 1.*

*Plin. Nat.*  
*l. 36 c. 26.*

opinion, severely dehorting all his followers from prostituting Mathematical principles, unto common apprehension or practise. Like the envious Emperour *Tiberius*, who is reported to have killed an Artificer for making glass malleable, fearing lest thereby the price of metals might be debased. So he, in his superstition to Philosophy, would rather chuse to deprive the world of all those usefull and excellent inventions, which might be thence contrived, than to expose that profession unto the contempt of the ignorant vulgar.

*Arist.*  
*Quæst.*  
*Mechan.*

But his Scholar *Aristotle*, (as in many other particulars, so likewise in this) did justly oppose him, and became himself one of the first Authors, that hath writ any methodical Discourse concerning these arts, chusing rather a certain and general benefit, before the hazard that might accrue from the vain and groundless dis-respects of some ignorant persons. Being so far from esteeming Geometry dishonoured by the applicati-  
on



on of it to Mechanical practises, that he rather thought it to be thereby adorned, as with curious variety, and to be exalted unto its natural end. And whereas the Mathematicians of those former ages, did possess all their learning, as covetous men do their wealth, only in thought and notion; the judicious *Aristotle*, like a wise Steward, did lay it out to particular use and improvement, rightly preferring the reality and substance of publick benefit, before the shadows of some retired speculation, or vulgar opinion.

Since him there have been divers other Authors, who have been eminent for their writings of this nature. Such were *Hero Alexandrinus*, *Hero Mechanicus*, *Pappus Alexandrinus*, *Proclus Mathematicus*, *Vitruvius*, *Guidus Ubaldus*, *Henricus Monantholinus*, *Galileus*, *Guevara*, *Mersennus*, *Bettinus*, &c. Besides many others, that have treated largely of several engines, as *Augustine Ramelli*, *Vittorio Zoncha*, *Jacobus Bessonius*, *Vegetius*, *Lipsius*.



Most of which Authours I have perused, and shall willingly acknowledge my self a debtor to them for many things in this following Discourse.

### C A P. II.

*Concerning the name of this Art. That it may properly be styled liberall, The subject and nature of it.*

**T**He word *Mechanick* is thought to be derived ἀπὸ τῆ μηχανῆς καὶ ἀνείν, *multum ascendere, pertingere*: intimating the efficacy and force of such inventions. Or else ἀπὸ τοῦ χαλκῆν, (saith *Eustathius*) *quia hiscere non finit*, because these arts are so full of pleasant variety; that they admit not either of sloth or weariness.

According to ordinary signification, the word is used in opposition to the liberall arts: whereas in propriety of speech those employments alone may be styled *illiberall*, which require onely some bodily exercise, as manufactures, trades, &c. And on the  
con-

*Lysius.*  
*Polyorccc.*  
*l. i. Dia-*  
*log. 3.*  
That's a  
senseless  
absurd E-  
rymology  
imposed by  
some, *Quia*  
*intellectus*  
*in eis mæ-*  
*cha:ur*, as  
it these arts  
did prosti-  
tute and a-  
dulterate  
the under-  
standing.

contrary that discipline, which discovers the general causes, effects, and properties of things, may truly be esteemed as a *species* of Philosophy.

But here it should be noted, that this art is usually distinguished into a twofold kind:

1. *Rational.*

2. *Cheirurgical.*

The *Rational* is that which treats of those principles, and fundamentall notions, which may concern these Mechanical practises.

The *Cheirurgical* or *Manuall*, doth refer to the making of these instruments, and the exercising of such particular experiments. As in the works of Architecture, Fortifications, and the like.

The first of these, is the subject of this discourse, and may properly be stiled *liberall*, as justly deserving the prosecution of an ingenuous mind. For if we consider it according to its birth and original, we shall find it to spring from honourable parentage, being produced by *Geometry* on the  
one

Pappus  
Proem in  
Colleg.  
Mathem.  
1.8.

one side, and *natural Philosophy* on the other. If according to its use and benefit, we may then discern that to this should be referred all those arts and professions, so necessary for humane society, whereby nature is not only directed in her usual course, but sometimes also commanded against her own law. The particulars that concern Architecture, Navigation, Husbandry, Military affairs, &c. are most of them reducible to this art, both for their invention and use.

Those other disciplines of Logick, Rhetorick, &c. do not more protect and adorn the mind, than these Mechanical powers do the body.

And therefore are they well worthy to be entertained with greater industry and respect, than they commonly meet with in these times; wherein there be very many that pretend to be masters in all the liberal arts, who scarce understand any thing in these particulars.

The subject of this art is concerning the heaviness of several bodies,  
or

or the proportion that is required betwixt any weight, in relation to the power which may be able to move it. And so it refers likewise to violent and artificial motion, as Philosophy doth to that which is natural.

The proper end for which this art is intended, is to teach how by understanding the true difference betwixt the *weight* and the *power*, a man may adde such a fitting supplement to the strength of the power, that it shall be able to move any conceivable weight, though it should never so much exceed that force, which the power is naturally endowed with.

The art it self may be thus described, to be a Mathematical discipline, which by the help of Geometrical principles doth teach to contrive several weights and powers, unto any kind, either of motion or rest, according as the Artificer shall determine.

If it be doubted how this may be esteemed a *species* of Mathematicks, when as it treats of weights, and not of

Dav. Rivaltus  
præf. in lib.  
Archim.  
de centro  
gravitatis.



of quantity ; For satisfaction to this, there are two particulars considerable.

1. *Mathematicks* in its latitude is usually divided into *pure* and *mixed*. And though the *pure* do handle only *abstract quantity* in the *general*, as *Geometry*, *Arithmetick* : yet that which is *mixed* doth consider the quantity of some *particular determinate* subject. So *Astronomy* handles the quantity of heavenly motions, *Musick* of sounds, and *Mechanicks* of weights & powers.

2. Heaviness or weight is not here considered, as being such a natural *quality*, whereby condensed bodies do of themselves *tend downwards* ; but rather as being an affection, whereby they may be measured. And in this sense *Aristotle* himself referres it amongst the other *species* of *quantity*, as having the same proper essence, which is to be compounded of integral parts. So a pound doth consist of ounces, drams, scruples. Whence it is evident, that there is not any such repugnancy in the subject of this art, as may hinder it from being a true *species* of *Mathematicks*.

CAP.

*Metaph. l.*  
10. c. 2.



## CAP. III.

*Of the first Mechanical faculty, the Balance.*

THE Mechanical faculties, by which the experiments of this nature must be contrived, are usually reckoned to be these six:

1. <i>Libra.</i>	1. <i>The Ballance.</i>
2. <i>Vectis.</i>	2. <i>The Leaver.</i>
3. <i>Axis in Peritrochio.</i>	3. <i>The Wheel.</i>
4. <i>Trochlea.</i>	4. <i>The Pulley.</i>
5. <i>Cuneus.</i>	5. <i>The Wedge.</i>
6. <i>Cochlea.</i>	6. <i>The Screw.</i>

Unto some of which, the force of all Mechanical inventions must necessarily be reduced. I shall speak of them severally and in this order.

First, concerning the Ballance; this, and the Leaver are usually confounded together, as being but one faculty, because the general grounds and proportions of eithers force is so exactly the same. But for better distinction, and  
more

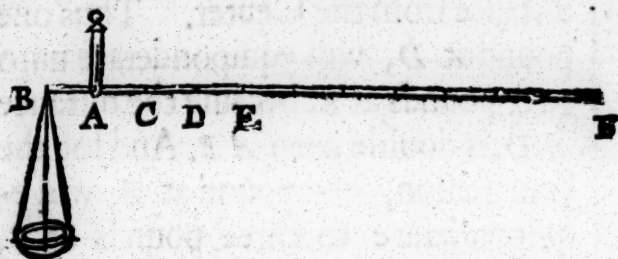
more clear discovery of their natures, I shall treat of them severally.

The first invention of the ballance is commonly attributed to *Astrea*, who is therefore deified for the goddess of justice; and that instrument it self advanced amongst the celestial signs.

The particulars concerning it are so commonly known, and of such easie experiment, that they will not need any large explication. The chief end and purpose of it, is for the distinction of several ponderosities; For the understanding of which, we must note, that if the length of the sides in the Ballance, and the weights at the ends of them be both mutually equal, then the Beam will be in a horizontal situation. But on the contrary, if either the weights alone be equal, and not their distances, or the distances alone, and not the weights, then the Beam will accordingly decline.

As in this following diagram.

Sup-



Suppose an equal weight at *C*, unto that at *B*, (which points are both equally distant from the center *A*,) it is evident that then the beam *B F*, will hang horizontally. But if the weight supposed at *C*, be unequal to that at *B*, or if there be an equal weight at *D E*, or any of the other unequal distances; the Beam must then necessarily decline.

With this kind of Ballance, it is usual by the help only of one weight, to measure sundry different gravities, whether more or less, than that by which they are measured. As by the example here described, a man may with one pound alone, weigh any other body within ten pounds, because the heaviness of any weight doth

*Ca. 4m,*  
*Subtil. l. 1.*

doth increase proportionably to its distance from the Center. Thus one pound at *D*, will equiponderate unto two pounds at *B*, because the distance *AD*, is double unto *AB*. And for the same reason, one pound at *E*, will equiponderate to three pounds at *B*, and one pound at *F*, unto ten at *B*, because there is still the same disproportion betwixt their several distances.

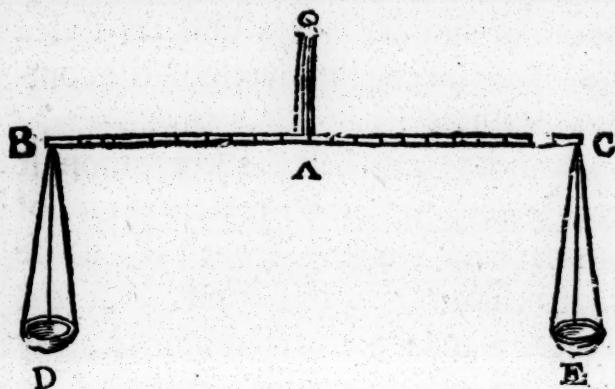
This kind of Ballance is usually styled *Romana, statera*. It seems to be of ancient use, and is mentioned by *Aristotle* under the name of *σάλαγξ*.

Hence it is easie to apprehend, how that false ballance may be composed so often condemned by the wise man, as being an abomination to the Lord. If the sides of the Beam be not equally divided, as suppose one have 10 parts, and the other 11, then any two weights that differ according to this proportion, ( the heavier being placed on the shorter side, and the lighter on the longer ) will equiponderate. And yet both the scales being empty, shall hang in *equilibrio*,

*Mechan.*  
ca. 21.

*Prov.* 11. 1  
ca. 16. 11.  
*Item. cap.*  
20. 10. 23.  
*Pappus.*  
*Collect.*  
*Mathem.*  
1. 8.

as if they were exactly just and true, as in this description.



Suppose  $AC$ , to have 11 such parts, whereof  $AB$ , has but 10, and yet both of them to be in themselves of equal weight; it is certain, that whether the scales be empty, or whether in the scale  $D$ , we put 11 pound, and at  $E$ , 10 pound, yet both of them shall equiponderate, because there is just such a disproportion in the length of the sides  $AC$ , being unto  $AB$ , as 11 to 10.

The frequency of such coufenages in these dayes, may be evident from common experience: and that they were used also in former ages, may  
C
appear



Question.  
Mechan.

c. 2.

Budaus.

Hence the

proverb

Zygofta: i.

ca fides.

appear from *Aristotles* testimony concerning the Merchants in his time. For the remedying of such abuses the Ancients did appoint divers Officers styled *Ζυγοστάται*, who were to overlook the common measures.

So great care was there amongst the Jewes for the preservation of commutative justice from all abuse and falsification in this kind, that the publick standards and originals, by which all other measures were to be tryed and allowed, were with much religion preserved in the sanctuary, the care of them being committed to the Priests and Levites, whose office it was to look unto *all manner of measures and size*. Hence is that frequent expression, *According to the shekel of the Sanctuary*; and that Law, *All thy estimations shall be according to the shekel of the Sanctuary*, which doth not refer to any weight or coin, distinct from, and more then the vulgar, ( as some fondly conceive ) but doth only oblige men in their dealing and traffique to make use of such  
just

1 Chron.

23. 29.

Exod. 30.

3.

Lev. 27. 25

just measures, as were agreeable unto the publick standards that were kept in the Sanctuary.

The manner how such deceitfull ballances may be discovered, is by changing the weights into each other scole, and then the inequality will be manifest.

From the former grounds rightly apprehended, it is easie to conceive how a man may find out the just proportion of a weight, which in any point given, shall equiponderate to severall weights given, hanging in severall places of the Beam.

Some of these ballances are made so exact, (those especially which the refiners use) as to be sensibly turned with the eightieth part of a grain: which (though it may seem very strange) is nothing to what \* *Capellus* relates of one at *Sedan*, that would turn with the four hundredth part of a grain.

There are severall contrivances to make use of these in measuring the weight of blowes, the force of powder,

Mester  
Greaves  
Roman:  
too.

\* De ponderibus & nummis  
l. 1.

the strength of strings, or other oblong substances, condensed air, the distinct proportion of several metals mixed together, the different gravity of divers bodies in the water, from what they have in the open air, with divers the like ingenuous inquiries.

## CAP. IV.

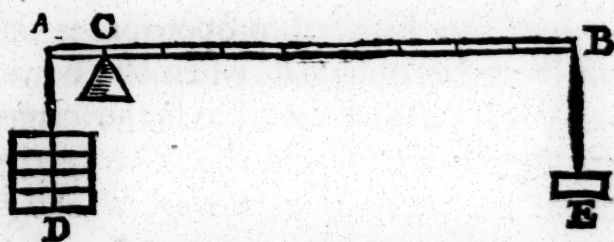
*Concerning the second Mechanick faculty, the Leaver.*

**T**He second Mechanical faculty, is the Leaver; the first invention of it is usually ascribed to *Neptune*, and represented by his Trident, which in the Greek are both called by one name, and are not very unlike in form, being both of them somewhat broader at one end, than in the other parts.

There is one main principle concerning it, which is (as it were) the very sum and epitome of this whole art. The meaning of it is thus expressed by *Aristotle*,  $\delta\ \tau\omicron\ \kappa\iota\nu\acute{\epsilon}\mu\epsilon\nu\omicron\nu\ \beta\acute{\alpha}\epsilon\varsigma\ \pi\epsilon\delta\varsigma\ \tau\omicron\ \kappa\iota\nu\acute{\epsilon}\nu\cdot\tau\omicron\ \mu\acute{\eta}\kappa\omicron\varsigma\ \pi\epsilon\delta\varsigma\ \tau\omicron\ \mu\acute{\eta}\kappa\omicron\varsigma\ \alpha\nu\lambda\iota\pi\acute{\epsilon}\pi\omicron\nu\theta\epsilon\nu$ . That

μόχλῳ.  
A. i. i. i. i. i.  
uast.  
Mechan.  
cap. 4.  
Archime-  
des. de E-  
quipende-  
rans. l. 1.  
prop. 7.  
Vernvūus  
Architect.  
l. 10. c. 8.

is, as the weight is to an equivalent power, so is the distance betwixt the weight and the center, unto the distance betwixt the center and the power, and so reciprocally. Or thus, the power that doth equiponderate with any weight, must have the same proportion unto it, as there is betwixt their several distances from the center or fulciment : as in this following figure.



Where suppose the Leaver to be represented by the length  $A B$ , the center or \* prop at the point  $C$ . the weight to be sustained  $D$ , the power that doth uphold it  $E$ .

Now the meaning of the foresaid principle doth import thus much; that the power at *E*, must bear the same

This  
 stoile cal  
 τανόχ  
 λιογ  
 Vau m  
 pr. ff.  
 uhardus,  
 Fulcimen-  
 tum, Dan  
 Barbarus,  
 Scabellum.



same proportion to the weight  $D$ , as the distance  $C A$ , doth to the other  $C B$ ; which, because it is octuple in the present example, therefore it will follow that one pound at  $B$ , or  $E$ , will equiponderate to eight pounds at  $A$ , or  $D$ , as is expressed in the figure. The ground of which maxime is this, because the point  $C$ , is supposed to be the center of gravity, on either side of which, the parts are of equall weight.

And this kind of proportion is not onely to be observed when the power doth *press downwards*, (as in the former example) but also in the other species of violent motion, as *lifting*, *drawing*, and the like. Thus if the prop or fulciment were supposed to be at the extremity of the Leaver,



As



As in this Diagram at *A*, then the weight *B*, would require such a difference in the strengths or powers that did sustain it, as there is betwixt the several distances *AC*, and *BC*. For as the distance *AB*, is unto *AC*, so is the power at *C*, to the weight at *B*; that is, the power at *A*, must be double to that at *C*, because the distance *BC*, is twice as much as *BA*. From whence it is easie to conceive, how any burden carried betwixt two persons, may be proportioned according to their different strengths. If the weight were imagined to hang at the number 2, then the power at *C*, would sustain but two of those parts, whereof that at *A*, did uphold 16. If it be supposed at the figure (3) then the strength at *C*, to that at *A*, would be but as three to fifteen. But if it were situated at the figure (9) then each of the extremities would participate of it alike, because that being the middle, both the distances are equal. If at the number (12) then the strength at *C*, is required to be

*C* 4                      double

The right understanding of this doth much conduce to the explication of the Pulley.

double unto that at *A*. And in the like manner are we to conceive of the other intermediate divisions.

Thus also must it be, if we suppose the power to be placed betwixt the fulcrum and the weight, as in this example.



Where, as *AC*, is to *AB*, so is the power at *B*, to the weight at *C*.

Hence likewise may we conceive the reason why it is much harder to carry any long substance, either on the shoulders, or in the hand, if it be held by either of the extrems, than if it be sustained by the middle of it. The strength that must equiponderate at the nearer end, sometimes increasing the weight almost double to what it is in it self.

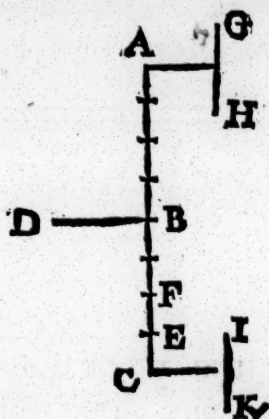
Imagine



Imagine the point *A*, to be the place where any long substance ( as suppose a Pike ) is sustained ; it is evident from the former principle, that the strength at *B*, ( which makes it lye level ) must be equal to all the length *A C*, which is almost the whole Pike.

And as it is in the depressing, or elevating, so likewise is it in the drawing of any weight, as a Coach, Plow, or the like.

Let



Let the line  $DB$ , represent the Pole or Carriage on which the burden is sustained, and the line  $AC$ , the cross barre ; at each of its extremities, there is a several spring-tree  $GH$ , and  $IK$ , to which either horses or oxen may be fastned. Now because  $A$ , and  $C$ , are equally distant from the middle  $B$ , therefore in this case the strength must be equal on both sides ; but if we suppose one of these spring-trees to be fastned unto the points  $E$ , or  $F$ , then the strength required to draw on that side, will be so much more, as the distance  $EB$ , or  $FB$ , is less than that of  $AB$  ; that is, either as three to four, as  $EB$ , to  $BA$ ,

$BA$ , or as one to two, as  $FB$ , to  $BA$ . So that the beast fastned at  $A$ , will not draw so much by a quarter, as the other at  $E$ , and but half as much as one at  $F$ .

Whence it is easie to conceive how a husbandman ( *cum inaequales veniunt ad aratra iuveni* ) may proportion the labour of drawing according to the several strength of his oxen.

Unto this Mechanicall faculty should be reduced sundry other instruments in common use. Thus the oares, steern, masts, &c. according to their force, whereby they give motion to the ship, are to be conceived under this head.

Thus likewise for that engine, whereby Brewers and Dyers do commonly draw water, which *Aristotle* calls *μηλόνοιον*, and others *Tollenon*. This being the same kind of instrument, by which *Archimedes* drew up the ships of *Marcellus*.

*Arist. Mechan. c. 5, 6, 7. Vide Guevar. Comment.*

*Mechan. c. 29. Pet. Crinitus, de honesta Disciplina l. 19. c. 2. calls it corruptly Tellenon.*



## CAP. V.

*How the natural motion of living creatures is conformable to these artificial rules.*

**T**He former principle being already explained, concerning artificial and dead motions, it will not be altogether impertinent, if in the next place, we apply it unto those that are natural in living bodies, and examine whether these also are not governed by the same kind of proportions.

In all perfect living creatures, there is a twofold kind of motive instruments :

1. Primary, the muscles.
2. Secondary, the members.

The muscles are naturally fitted to be instruments of motion, by the manner of their frame and composition; consisting of flesh as their chief material, and besides of Nerves, Ligatures, Veins, Arteries, and Membranes.

The

The *Nervus* serve for the conveyance of the motive faculty from the brain. The *Ligatures* for the strengthening of them, that they may not flag and languish in their motions. The *Veins* for their nourishment. The *Arteries* for the supplying of them with spirit, and natural vigor. The *Membranes* for the comprehension or inclosure of all these together, and for the distinction of one muscle from another. There are besides divers *fibra* or hairy substances, which nature hath bestowed for the farther corroborating of their motions; these being dispersed through every muscle, do so joyn together in the end of them, as to make intire nervous bodies, which are called *Tendones*, almost like the gristles. Now this (saith *Galen*) may fitly be compared to the broader part of the Leaver, that is put under the weight, which, as it ought to be so much the stronger, by how much it is put to a greater force; so likewise by this, doth nature inable the muscles and nerves  
for

*De Placit*  
*Hippoc. &*  
*Plac. or. l. 1*  
*ca. 19.*

for those motions, which otherwise would be too difficult for them.

Whence it may evidently appear, that according to the opinion of that eminent Physitian, these natural motions are regulated by the like grounds with the artificial.

De usu par-  
tium. l. 1.  
c. 2.

2. Thus also is it in those secondary instruments of motion, the members : amongst which, the hand is *ὄργανον ὄργανον*, the instrument of instruments ( as *Galen* styles it ; ) and as the soul of man doth bear in it the image of the divine wisdom and providence, so this part of the body seems in some sort to represent the omnipotency of God, whilst it is able to perform such various and wonderfull effects by the help of this art. But now for its own proper natural strength, in the lifting any great weight, this is alwayes proportioned according to its extension from the body, being of least force when it is fully stretched out, or at arms end, ( as we say ) because then the shoulder joynt is as the center of its

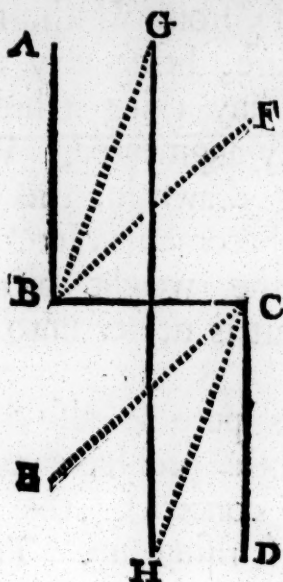
its motion, from which, the hand in that posture, being very remote, the weight of any thing it holds must be accordingly augmented. Whereas the arm being drawn in, the elbow joynt doth then become its center, which will diminish the weight proportionably, as that part is neerer unto it than the other.

To this purpose also, there is another subtle probleme proposed by *Aristotle*, concerning the postures of sitting and rising up. The quære is this, Why a man cannot rise up from his seat, unless he first, either bend his body forward, or thrust his feet backward.

*Mechan.*  
c. 31.

In the posture of sitting, our legs are supposed to make a right angle with our thighs, and they with our backs as in this figure.

Where



Where let  $AB$ , represent the back,  $BC$ , the thighs,  $CD$ , the legs. Now it is evident, that a man cannot rise from this posture, unless either the back  $AB$ , do first incline unto  $F$ , to make an acute angle with the thighs  $BC$ ; or else that the legs  $CD$ , do incline towards  $E$ , which may also make an acute angle with the thighs  $BC$ ; or lastly, unless both of them do decline to the points  $GH$ , where they may be included in the same perpendicular.

For



For the resolution of which, the Philosopher proposes these two particulars.

1. A right angle (saith he) is a kind of equality, and that being naturally the cause of rest, must needs be an impediment to the motion of rising.

2. Because when either of the parts are brought into an acute angle, the head being removed over the feet, or they under the head; in such a posture the whole man is much neerer disposed to the forme of standing, wherein all these parts are in one streight perpendicular line; then he is by the other of right angles, in which the back and legs are two parallels; or that of turning these streight angles into obtuse, which would not make an erect posture, but declining.

But neither of these particulars (as I conceive) doe fully satisfie the present quære, neither doe the Commentators, *Monantholius*, or *Guevara*, better resolve it. Rather suppose *BC*, to be as a Vectis or Leaver, to-

D

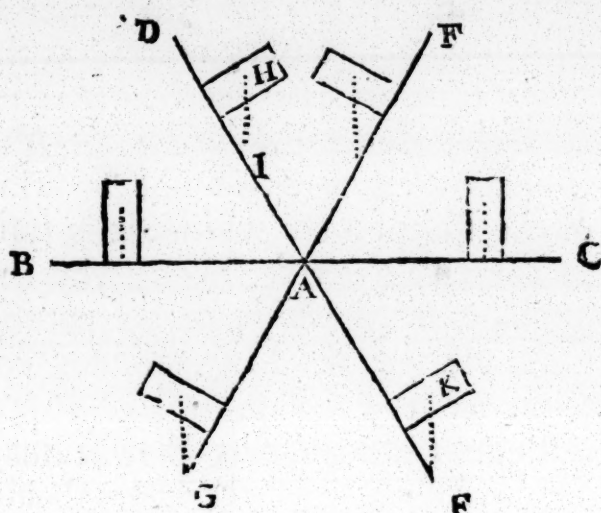
wards

wards the middle of which is the place of the fulciment,  $A B$ , as the weight,  $C D$ , the power that is to raise it.

Now the body being situate in this rectangular forme, the weight  $A B$ , must needs be augmented proportionably to its distance from the fulciment, which is about halfe the thighs; whereas if we suppose either the weight to be inclined unto  $F$ , or the power to  $E$ , or both of them to  $G H$ , then there is nothing to be lifted up but the bare weight it self, which in this situation is not at all increased with any addition by distance.

For in these conclusions concerning the Leaver, we must alwayes imagine that point which is touched by a perpendicular from the center of gravity, to be one of the terms. So that the diverse elevation or depression of the instrument, will inferre a great alteration in the weight it self, as may more clearly be discerned by this following Diagram.

Where



Where *A*, is supposed to be the place of the prop or fulciment, *BC*, a Leaver which stands horizontally, the power and the weight belonging unto it, being equall both in themselves, and also in their distances from the prop.

But now suppose this instrument to be altered according to the situation *DE*, then the weight *D*, will be diminished, by so much, as the perpendicular from its center of gravity

vity  $HI$ , doth fall nearer to the prop or fulciment at  $A$ . And the power at  $E$ , will be so much augmented, as the perpendicular from its center ( $KE$ ) does fall farther from the point at  $A$ . And so on the contrary in that other situation of the Leaver  $FG$ ; whence it is easie to conceive the true reason, why the inclining of the body, or the putting back of the leg, should so much conduce to the facility of rising.

Sir Fran:  
Bacon  
Nat. Hist.  
Exp. 73<sup>1</sup>.

From these grounds likewise may we understand, why the knees should be most weary in ascending, and the thighs in descending, which is, because the weight of the body doth bear most upon the knee-joynts, in raising it self up, and most upon the muscles of the thighs when it staves it self in coming down.

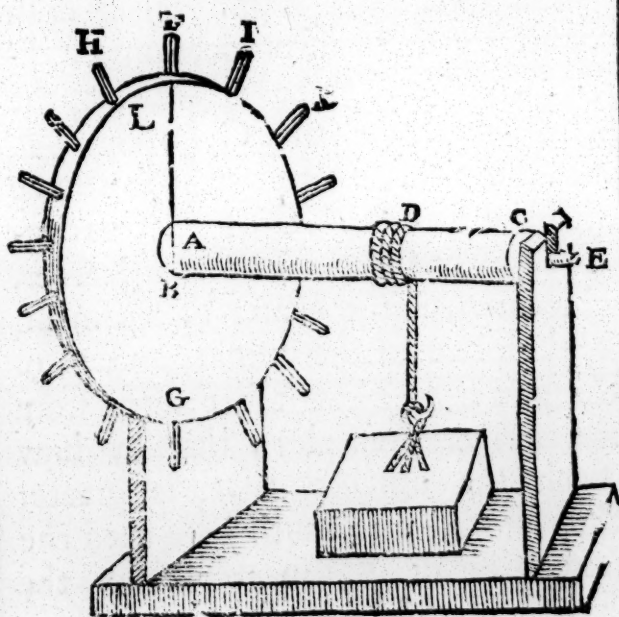
There are divers other naturall problemes to this purpose, which I forbear to recite. We doe not so much as goe, or sit, or rise, without the use of this Mechanicall Geometry.

CAP.

CAP. VI.  
*Concerning the Wheel.*

**T**He third Mechanicall faculty is commonly styled *axis in peritrochio*. It consists of an axis or cylinder, having a rundle about it, wherein there are fastned divers spokes, by which the whole may be turned round; according to this figure.

Called  
likewise  
*ὄρος. Arist.*  
*Mechan.*  
c. 14.



D 3

Where

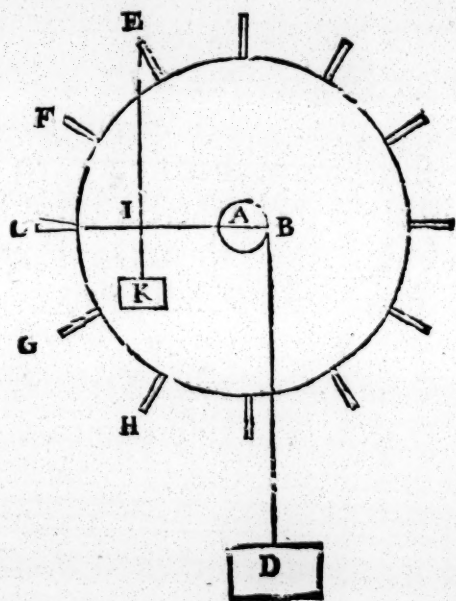


Where  $BC$ , does represent the Cylinder which is supposed to move upon a smaller Axis at  $E$ , ( this being all one in comparison to the severall proportions, as if it were a meere Mathematicall line )  $LG$ , is the rundle or wheel,  $HFIK$ , severall spokes or handles that are fastned in it ;  $D$ , the place where the cord is fastned for the drawing or lifting up of any weight.

The force of this instrument doth consist in that dis-proportion of distance, which there is betwixt the Semidiameter of the Cylinder  $AB$ , and the Semidiameter of the rundle with the spokes  $FA$ . For let us conceive the line  $FB$ , to be as a Leaver, wherein  $A$ , is the center or fulciment,  $B$ , the place of the weight, and  $F$ , of the power. Now it is evident from the former principles, that by how much the distance  $FA$ , is greater then  $AB$ , by so much lesse need the power be at  $F$ , in respect of the weight at  $B$ . Suppose  $AB$ , to be as the tenth part of  $AF$ , then the power

er or strength: which is but as a hundred pound at *F*, will be equall to a thousand pound at *B*.

For the clearer explication of this faculty, it will not be amisse to consider the form of it, as it will appear being more fully exposed to the view. As in this other Diagram.



Suppose *A B*, for the Semidiameter of the Axis or Cylinder, and *A C*, for the Semidiameter of the rundle, with the spokes; then the power

D 4<sup>th</sup> at

at  $C$ , which will be able to support the weight  $D$ , must bear the same proportion unto it, as  $AB$ , doth to  $AC$ : so that by how much shorter the distance  $AB$ , is in comparison to the distance  $AC$ , by so much lesse need the power be at  $C$ , which may be able to support the weight  $D$ , hanging at  $B$ .

And so likewise is it for the other spokes or handles  $EFGH$ , at either of which, if we conceive any power, which shall move according to the same circumference wherein these handles are placed, then the strength of this power will be all one, as if it were at  $C$ . But now supposing a dead weight hanging at any of them, (as at  $E$ ,) then the disproportion will vary. The power being so much lesse then that at  $C$ , by how much the line  $AC$ , is longer then  $AI$ . The weight  $K$ , being of the same force at  $E$ , as if it were hung at  $I$ , in which point the perpendicular of its gravity doth cut the Diameter.

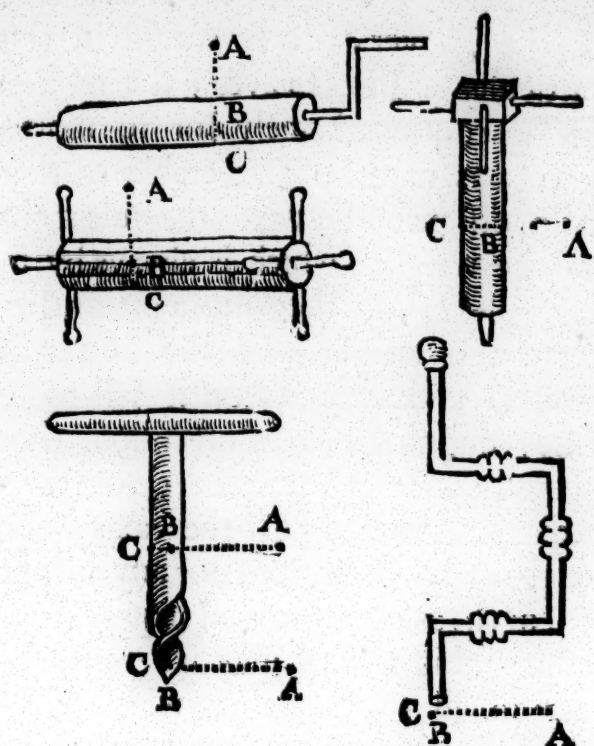
The chief advantage which this  
in-

instrument doth bestow, above that of the Leaver, doth consist in this particular. In a Leaver, the motion can be continued onely for so short a space, as may be answerable to that little distance betwixt the fulciment and the weight: which is always by so much lesser, as the disproportion betwixt the weight and the power is greater, and the motion it self more easie: But now in this invention, that inconvenience is remedied; for by a frequent rotation of the axis, the weight may be moved for any height or length, as occasion shall require.

Unto this faculty may we refer the force of all those engines which consist of wheels with teeth in them.

Hence also may we discern the reason why sundry instruments in common use, are framed after the like form with these following figures.

All



All which are but severall kinds of this third Mechanicall faculty. In which the points *A B C*; do represent the places of the power, the fulcrum, and the weight. The power being in the same proportion unto the weight, as *B C* is unto *B A*.

CAP.



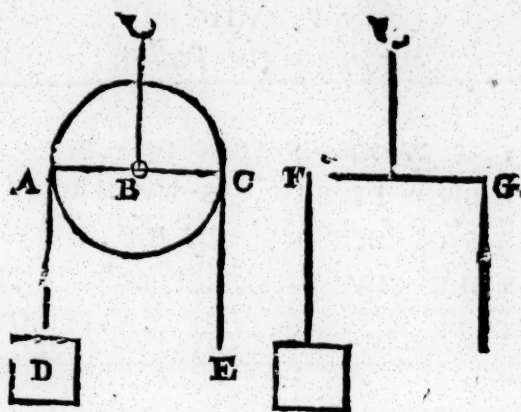
C A P. VII.  
Concerning the Pulley.

**T**Hat which is reckoned for the fourth Faculty, is the Pulley : which is of such ordinary use, that it needs not any particular description. The chief parts of it are divers little rundles, that are moveable about their proper axes. These are usually divided according to their several situations, into the upper and lower. If an engine have two of these rundles above, and two below, it is usually called  $\delta\iota\omega\alpha\varsigma\Theta$ , if three  $\tau\epsilon\iota\omega\alpha\varsigma\Theta$ , if many,  $\pi\omicron\lambda\upsilon\omega\alpha\varsigma\Theta$ .

*Arist. Me.  
chan. c. 19.*

The lower Pulleys onely do give force to the motion. If we suppose a weight to hang upon any of the upper rundles, it will then require a power, that in it self shall be fully equall for the sustaining of it.

The

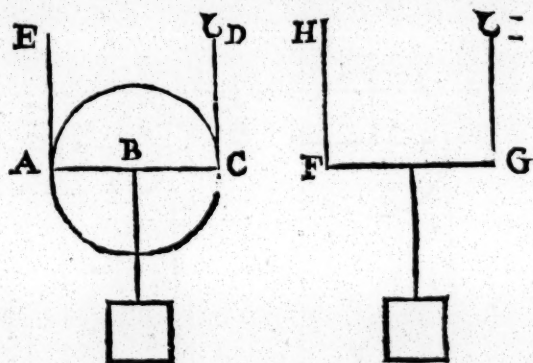


The Diameter  $A C$ , being as the beam of a ballance, of which  $B$  is the prop or center. Now the parts  $A$ , and  $C$ , being equally distant from this center, therefore the power at  $E$ , must be equal to the weight at  $D$ , it being all one as if the power and the weight were fastned by two severall strings at the ends of the ballance  $F G$ .

Now all the upper Pulleys being of the same nature, it must necessarily follow, that none of them do in themselves conduce to the easing of the power, or lightning the weight, but onely for the greater convenien-  
cy

cy of the motion, the cords by this means being more easily moved then otherwise they would.

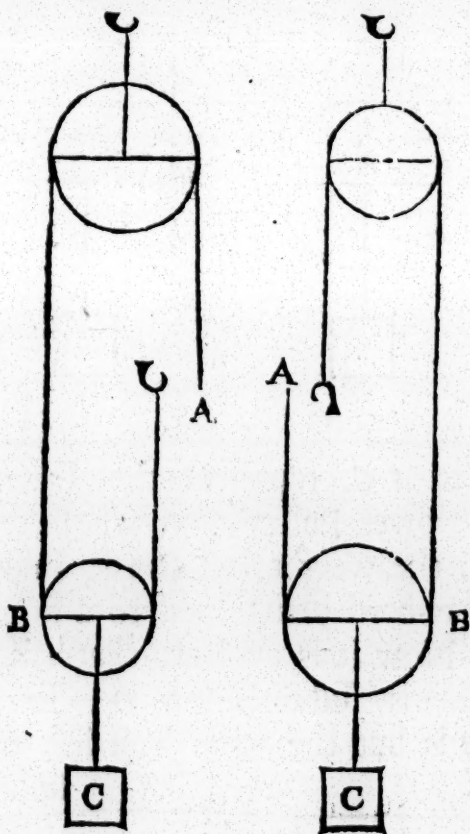
But now suppose the weight to be sustained above the Pulley, as it is in all those of the lower sort: and then the power which supports it, need be but half as much as the weight it self.



Let  $AC$ , represent the Diameter of a lower Pulley, on whose center at  $B$ , the weight is fastned, one end of the cord being tyed to a hook at  $D$ . Now it is evident, that halfe the weight is sustained at  $D$ , so that there is but the other half left to be sustained

sustained by the power at *E*. It being all one as if the weight were tyed unto the middle of the ballance *F G*, whose ends were upheld by two severall strings, *F H*, and *G I*.

And this same subduple proportion will still remain, though we suppose an upper Pulley joyned to the lower, as in these two other figures.



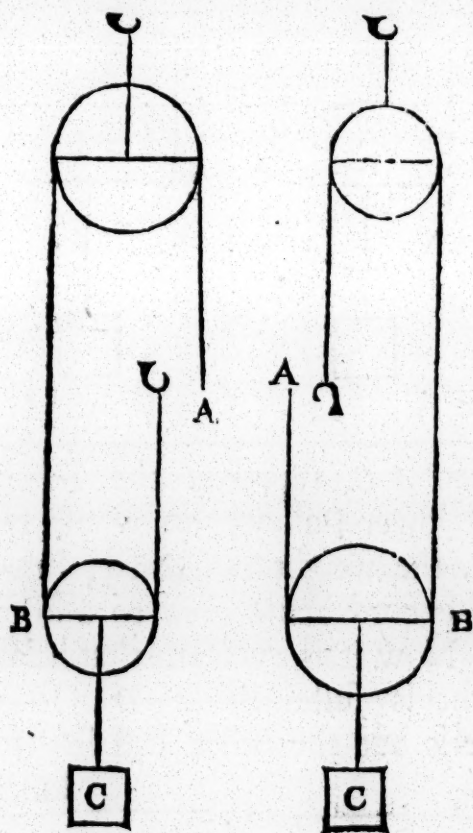
Where the power at *A*, is equall to the weight at *B*: Now the weight at *B*, being but half the ponderosity *C*, therefore the power at *A*, notwithstanding the addition of the upper rundle, must be equivalent to half the weight; and as the upper Pulley alone doth not abate any thing of the weight, so neither being joyned with the lower, and the same subduple difference betwixt the power and the weight, which is caused by the lower Pulley alone, doth still remain unaltered, though there be an upper Pulley added unto it.

Now as one of these under Pulleys doth abate halfe of that heavynesse which the weight hath in it self, and cause the power to be in a subduple proportion unto it, so two of them do abate halfe of that which remains, and cause a subquadruple proportion, betwixt the weight and the power; three of them a subsextuple, four a suboctuple: and so for five, or six, or as many as shall be required, they will all of them diminish  
the



sustained by the power at *E*. It being all one as if the weight were tyed unto the middle of the ballance *F G*, whose ends were upheld by two severall strings, *F H*, and *G I*.

And this same subduple proportion will still remain, though we suppose an upper Pulley joyned to the lower, as in these two other figures.



Where the power at *A*, is equal to the weight at *B*: Now the weight at *B*, being but half the ponderosity *C*, therefore the power at *A*, notwithstanding the addition of the upper rundle, must be equivalent to half the weight; and as the upper Pulley alone doth not abate any thing of the weight, so neither being joyned with the lower, and the same subduple difference betwixt the power and the weight, which is caused by the lower Pulley alone, doth still remain unaltered, though there be an upper Pulley added unto it.

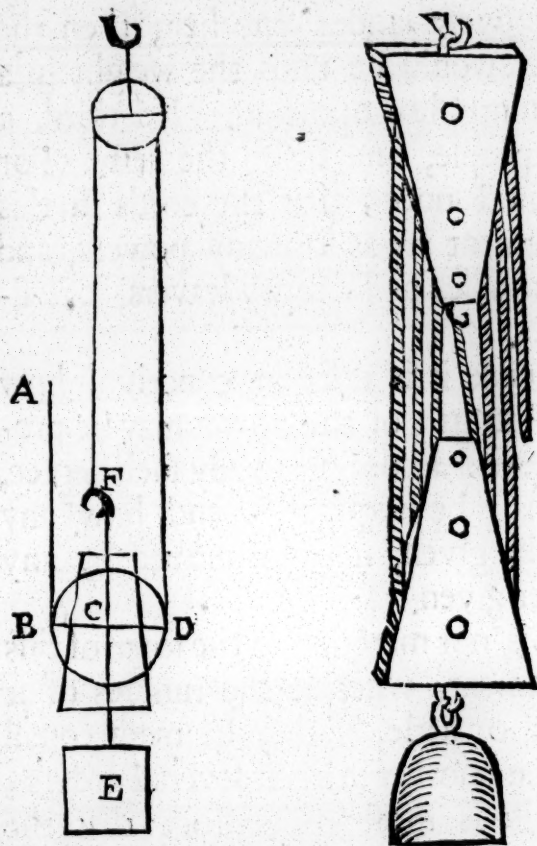
Now as one of these under Pulleys doth abate halfe of that heavynesse which the weight hath in it self, and cause the power to be in a subduple proportion unto it, so two of them do abate halfe of that which remains, and cause a subquadruple proportion, betwixt the weight and the power; three of them a subsextuple, four a suboctuple: and so for five, or six, or as many as shall be required, they will all of them diminish  
the

the weight according to this proportion.

Suppose the weight in it self to be 1200 pound, the applying unto it one of these lower Pulleys, will make it but as 600, two of them as 300, three of them as 150, &c.

But now, if we conceive the first part of the string to be fastned unto the lower Pulley, as in this other figure at *F* ;

then



then the power at *A*, will be in a sub-  
triple proportion to the weight *E*,  
because the heaviness would be then  
equally divided unto the three points  
of the lower Diameter *B*, *C*, *D*, each

*E*

of

of them supporting a like share of the burden. If unto this lower Pulley there were added another, then the power would be unto the weight in a subquintuple proportion. If a third, a subseptuple, and so of the rest. For we must note, that the cords in this instrument are as so many powers, and the rundles as so many leavers, or balances.

Hence it is easie to conceive, how the strength of the power may be proportioned according to any such degree, as shall be required ; and how any weight given, may be moved by any power given.

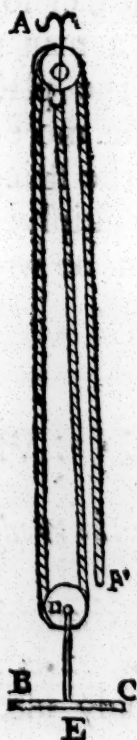
'Tis not materiall to the force of this instrument, whether the rundles of it be big or little, if they be made equall to one another in their severall orders ; But it is most convenient, that the upper should each of them increase as they are higher, and the other as they are lower, because by this means the cords will be kept from tangling.

These Pulleys may be multiplied  
ac-



according to sundry different situations, not onely when they are subordinate, as in the former examples, but also when they are placed collaterally.

From the former grounds it is easie to contrive a ladder, by which a man may pull himself up unto any height. For the performance of this, there is required onely an upper and a lower rundle:



To the uppermost of these at *A*, there should be fastned a sharp grapple or cramp of iron, which may be apt to take hold of any place where it lights. This part being first cast up and fastned, and the staffe *DE*, at the nether end, being put betwixt the legs, so that a man may sit upon the other *BC*, and take hold of the cord at *F*, it is evident that the weight of the person at *E*, will be but equall to half so much strength at *F*; so that a man may easily pull himself up to the place required, by leaning but little more then half of his own weight on the string *F*. Or if the Pulleyes be multiplyed, this experiment may then be wrought with lesse labour.

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C A P. VIII.

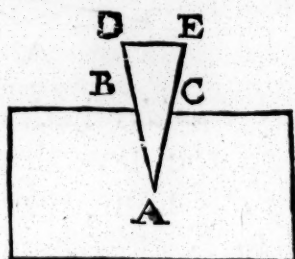
*of the Wedge.*

**T**He fift Mechanicall faculty is the Wedge, which is a known instrument, commonly used in the cleaving

ving of wood. The efficacy and great strength of it may be resolved unto these two particulars:

1. The form of it.
2. The manner whereby the power is impressed upon it, which is by the force of blows.

1. The form of it represents (as it were) two Leavers.

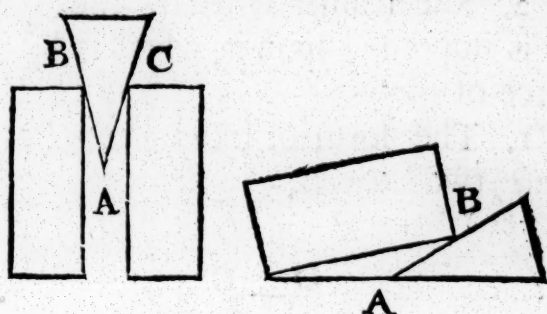


Each side  $AD$ , and  $AE$ , being one, the points  $BC$ , being in stead of several props or fulciments; the weight to be moved at  $A$ , and the power that should move it, being applied to the top  $DE$ , by the force of some stroak or blow : as *Aristotle* hath explained the several parts of this faculty. But now, because this instrument may be so used that the

*Mechan.*  
c. 18.

E 3 point

point of it shall not touch the body to be moved, as in these other figures:



Therefore *Ubaldu*s hath more exactly applied the several parts of it according to this form, that the point *A*, should be as the common fulcriment, in which both the sides do meet, and (as it were) uphold one another ; the points *B*, and *C*, representing that part of the Leavers where the weight is placed.

It is a general rule, that the more acute the angles of these wedges are, by so much more easie will their motion be ; the force being more easily impressed, and the space wherein the body is moved, being so much the lesse.

The



The second particular whereby this faculty hath its force, is the *manner* whereby the power is imprest upon it, which is by a stroke or blow; the efficacy of which doth much exceed any other strength. For though we suppose a wedge being laid on a peice of timber, to be pressed down with never so great a weight; nay, though we should apply unto it the power of those other Mechanicall engines, the Pulley, Screw, &c. yet the effect would be scarce considerable in comparison to that of a blow. The true reason of which, is one of the greatest subtilties in nature, nor is it fully rendred by any of those who have undertaken the resolution of it. *Aristotle*, *Cardan*, and *Scaliger*, do generally ascribe it unto the swifnesse of that motion; But there seems to be something more in the matter then so; for otherwise it would follow that the quick stroak of a light hammer, should be of greater efficacy, then any softer and more gentle striking of a great

E 4                      sledge.

\* *Mechan.*  
c. 10.  
*Subtil.* l. 17  
*Exercit.*  
331.



sledge. Or according to this, how should it come to passe, that the force of an arrow or bullet discharged near at hand ( when the impressi<sup>o</sup>n of that violence, whereby they are carried, is most fresh, and so in probability the motion at its swiftest ) is yet notwithstanding much lesse then it would be at a greater distance. There is therefore further considerable, the quality of that instrument by which this motion is given, and also the conveniency of distance through which it passes.

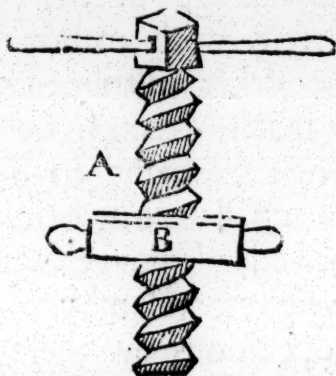
Unto this faculty is usually reduced the force of files, saws, hatchets, &c. which are as it were but so many wedges fastned unto a Vectis or Leaver.

C A P. IX.  
*Of the Screw.*

**T**Hat which is usually recited for the fixth and last Mechanick faculty, is the Screw, which is described to be a kind of wedge that is multiplied

plyed, or continued by a helicall revolution about a Cylinder, receiving its motion not from any stroak, but from a Vectis at one end of it. It is usually distinguished into two severall kinds: the male, which is meant in the former description, and the female, which is of a concave superficies.

*Pappus  
Collect.  
Mathemat.  
lib. 8.*



The former is noted in the figure with the letter *A*, the other with *F*.

*Aristotle* himself doth not so much as mention this instrument, which yet notwithstanding is of greater force and subtilty, then any of the rest. It is chiefly applied to the squeezing or pressing of things downwards,

wards, as in the Presses for Printing, for wine, oyl, and extracting the juice from other fruits. In the performance of which, the strength of one man may be of greater force, then the weight of a heavy mountain : It is likewise used for the elevating or lifting up of weights.

The advantage of this faculty above the rest, doth mainly consist in this : the other instruments doe require so much strength for the supporting of the weight to be moved, as may be equall unto it, besides that other super-added power whereby it is out-weighed and moved ; so that in the operations by these, a man does always spend himself in a continued labour.

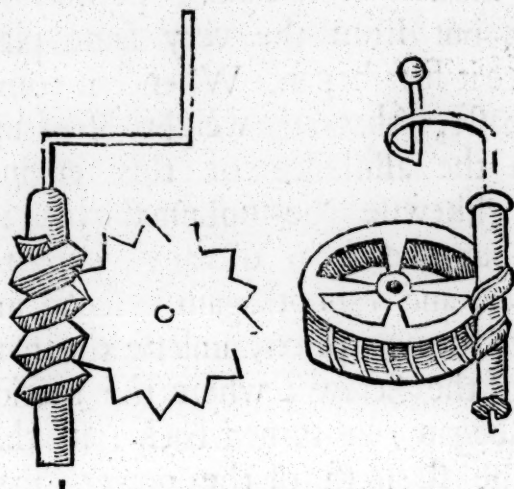
Thus (for example) a weight that is lifted up by a Wheel or Pulley, will of it self descend, if there be not an equall power to sustain it. But now in the composure of a Screw, this inconvenience is perfectly remedied ; for so much force as is communicated unto this faculty, from the  
power

power that is applied unto it; is still retained by the very frame and nature of the instrument it self; since the motion of it cannot possibly return, but from the very same place where it first began. Whence it comes to passe, that any weight lifted up, with the assistance of this engine, may likewise be sustained by it, without the help of any externall power, and cannot again descend unto its former place, unlesse the handle of the Screw ( where the motion first began ) be turned back: so that all the strength of the power, may be imployed in the motion of the weight, and none spent in the sustaining of it.

The chief inconvenience of this instrument is, that in a short space it will be screwed unto its full length, and then it cannot be of any further use for the continuance of the motion, unlesse it be returned back, and undone again as at the first. But this is usually remedied by another invention, commonly stiled a *perpetuall*



*tual screw, which hath the motion of a wheel, and the force of a screw, being both infinite.*



It is used  
in some  
Watches.

For the compofure of which, in-  
stead of the female, or concave screw,  
there must be a little wheel, with  
some notches in it, equivalent to  
teeth, by which the other may take  
hold of it, and turn it round, as in  
these other figures.

This latter engine does so far ex-  
ceed all other contrivances to this  
purpose, that it may justly seem a  
wonder why it is not of as common  
use



use in these times and places, as any of the rest.

## CAP. X.

*An enquiry into the magnificent works of the Ancients, which much exceeding our later times, may seem to inferre a decay in these Mechanicall Arts.*

**T**HUS have I briefly treated concerning the generall principles of Mechanicks, together with the distinct proportions betwixt the weight and the power in each severall faculty of it; Whence it is easie to conceive the truth and ground of those famous ancient monuments, which seem almost incredible to these following ages. And because many of them recorded by Antiquity, were of such vast labour and magnificence, and so mightily disproportionate to humane strength, it shall not therefore be impertinent unto the purpose I aim at, for to specify some  
of

of the most remarkable amongst them, and to enquire into the means and occasion upon which they were first attempted.

Li. 2 c. 175

Amongst the *Ægyptians*, we read of divers Pyramids, of so vast a magnitude, as time it self in the space of so many hundred years hath not yet devoured. *Herodotus* mentions one of them, erected by *Cleopes* an *Ægyptian* King, wherein there was not any one stone lesse then 30 foot long, all of them being fetched from *Arabia*. And not much after, the same Authour relates, how *Amasis* another *Ægyptian*, made himself a house of one entire stone, which was 21 cubits long, 14 broad, and 8 cubits high. The same *Amasis* is reported to have made the statue of a *Sphinx*, or *Ægyptian* cat, all of one single stone, whose length was 143 foot, its height 62 foot, the compasse of this statues head containing 102 foot. In one of the *Ægyptian* temples consecrated to *Jupiter*, there is related to be an Obelisk, consisting of 4 Smaragds

Plin. l. 36.  
ca. 12.

Plin. l. 37.  
cap. 5.

or

or Emeralds ; the whole is 40 cubits high, 4 cubits broad at the bottome, and two at the top. *Sesostris* the King of *Aegypt* in a temple at *Memphis*, dedicated to *Vulcan*, is reported to have erected two statues ; one for himself, the other for his wife, both consisting of two severall stones, each of which were 30 cubits high.

*Diodor Sicul. Biblioth. l. 1. Sect. 2.*

Amongst the Jewes we read in sacred Writ of *Solomons* Temple, which for its state and magnificence, might have been justly reckoned amongst the other wonders of the world, wherein besides the great riches of the materials, there were works too of as great labour. Pillars of brasie 18 cubits high, and 12 cubits round, great and costly stones for the foundation of it. *Iosephus* tels us that some of them were 40 cubits, others 45 cubits long. And in the same chapter he mentions the three famous Towres built by *Herod*, wherein every stone being of white marble, was 20 cubits long, 10 broad, and 5 high. And which was the greatest won-

*1 Kings 7. 15. cap. 5. v. 17*

*De bello Juda. l. 6. 6. 6.*

wonder, the old wall it self was situated on a steep rising ground, and yet the hils upon it, on the tops of which these Towers were placed, were about 30 cubits high, that 'tis scarce imaginable by what strength so many stones of such great magnitude should be conveyed to so high a place.

*Plin. l. 36.*

*c. 14.*

*Panciroll.*

*Deperd.*

*Tit. 3 2.*

Amongst the Grecians we read of the *Ephesian* Temple dedicated to *Diana*, wherein there were 127 columns, made of so many severall stones, each of them 60 foot high, being all taken out of the quarries in *Asia*. 'Tis storied also of the brazen *Colossus*, or great statue in the Island of *Rhodes*, that it was 70 cubits high. The thumbs of it being so big that no man could grasp one of them about with both his arms; when it stood upright, a ship might have passed berwixt the legs of it, with all its sails fully displayed; being thrown down by an earth-quake, the brasse of it did load 900 Camels. But above all ancient designs to this purpose, that would have been most wonder-

*Plin. l. 34.*

*c. 3.*

wonder-



wonderfull, which a Grecian Architect did propound unto *Alexander*, to cut the mountain *Athos* into the forme of a statue; which in his right hand should hold a Town capable of ten thousand men; and in his left a Vessel to receive all the water that flowed from the severall springs in the mountain. But whether *Alexander* in his ambition did fear that such an Idoll should have more honour then he himself, or whether in his good husbandry, hee thought that such a *Microcosme* ( if I may so style it ) would have cost him almost as much as the conquering of this great world, or what ever else was the reason, he refused to attempt it.

*Vitrus.*  
*Archit. l. 2.*

Amongst the *Romanes* we read of a brazen *Colossus*, made at the command and charges of *Nero*, which was 120 foot high; *Martiall* calls it *Sydereus*, or starry.

*Suet. Ner.*

*Hic ubi Sydereus proprius videt astra Colossus.* And it is storied of *M. Curio*, that he erected two *Theaters* suffici-

*Panciro.*  
*Deperd.*  
*Tit. 18.*

F

ently



ently capacious of people, contrived moveable upon certain hinges ; Sometimes there were severall playes and shewes in each of them, neither being any disturbance to the other ; and sometimes they were both turned about, with the people in them, and the ends meeting together, did make a perfect *Amphitheater* : so that the spectators which were in either of them, might joyntly behold the same spectacles.

*Idem* 31.

There were besides at *Rome* sundry *Obelisks*, made of so many intire stones, some of them 40, some 80, and others 90 cubits high. The chief of them were brought out of *Ægypt*, where they were dug out of divers quarries, and being wrought into form, were afterwards (not without incredible labour, and infinite charges) conveyed unto *Rome*. In the year 1586, there was erected an old *Obelisk*, which had been formerly dedicated unto the memory of *Julius Caesar*. It was one solid stone, being an Ophite or kind of spotted Marble. The height of it was 107 foot, the breadth of it  
at

at the bottome was 12 foot, at the top 8. Its whole weight is reckoned to be 956148 pounds, besides the heaviness of all those instruments that were used about it, which (as it is thought) could not amount to lesse then 1042824 pounds. It was transplaced at the charges of Pope *Sixtus* the fifth, from the left side of the *Vatican*, unto a more eminent place about a hundred foot off, where now it stands. The moving of this *Obelisk* is celebrated by the writings of above 56 severall Authours, (saith *Monantholius*) all of them mentioning it, not without much wonder and praise. Now if it seem so strange and glorious an attempt to move this *Obelisk* for so little a space, what then may we think of the carriage of it out of *Ægypt*, and divers other far greater works performed by Antiquity? This may seem to infer, that these *Mechanicall* arts are now lost, and decayed amongst the many other ruines of time: which yet notwithstanding cannot be granted, without much ingrati-

*Comment.  
in Mechan.  
Arist. c. 19.*

tude to those learned men, whose labours in this kind we enjoy, and may justly boast of. And therefore for our better understanding of these particulars, it will not be amisse to enquire both *why*, and *how*, such works should be performed in those former and ruder ages, which *are not*, and (as it should seem) *cannot* be effected in these later and more learned times. In the examination of which, we shall find that it is not the want of art that disables us for them, since these Mechanicall discoveries are altogether as perfect, and (I think) much more exact now, then they were heretofore; but it is, because we have not either the same *motives*, to attempt such works, or the same *means* to effect them as the Ancients had.

CAP.

## CAP. XI.

*That the Ancients had divers motives and means for such vast magnificent works, which we have not.*

**T**He *motives* by which they were excited to such magnificent attempts, we may conceive to be chiefly three :

{ *Religion.*  
 { *Policy.*  
 { *Ambition.*

1. *Religion.* Hence was it that most of these stately buildings were intended for some sacred use, being either Temples or \* Tombes, all of them dedicated to some of their Deities. It was an in-bred principle in those ancient Heathen, that they could not chuse but merit very much by being liberal in their outward services. And therefore we read of *Cræsus*, that being overcome in a battel, and taken by *Cyrus*, he did revile the gods of ingratitude, because they had no better care of him, who had so frequently

\* As Pyramids, Obelisks.

*Herodot.*  
 l. 1.



adored them with costly oblations. And as they did conceive themselves bound to part with their lives in defence of their religion : so likewise to employ their utmost power and estate, about any such design, which might promote or advance it. Whereas now, the generality of men, especially the wisest sort amongst them, are in this respect of another opinion, counting such great and immense labours, to be at the best but glorious vanities. The Temple of *Solomon* indeed was to be a type, and therefore it was necessary that it should be so extraordinarily magnificent, otherwise perhaps a much cheaper structure might have been as commendable and serviceable.

2. *Policy*, that by this means they might find out employment for the people, who of themselves being not much civilized, might by idleness quickly grow to such a rudeness and barbarisme, as not to be bounded within any laws of government. Again, by this means the riches of the kingdom



dome did not lye idly in their kings treasuries, but was always in motion, which could not but be a great advantage and improvement to the Common-wealth. And perhaps some of them feared lest it they should leave too much money unto their successors, it might be an occasion to in-snare them in such idle and vain courses as would ruine their kingdoms. Whereas in these later ages none of all these politick incitements can be of any force, because now there is imployment enough for all, and money little enough for every one.

3. *Ambition* to be known unto posterity; and hence likewise arose that incredible labour and care they bestowed to leave such monuments behinde them, as might \* *continue for ever*, and make them famous unto all after ages: This was the reason of *Abshalons* pillar, spoken of in Scripture, *to keep his name in remembrance*. And doubtlesse this too was the end which many other of the Ancients have aimed at, in those (as they

\* Psal. 49.  
21.

2 Sam. 18.  
18.

thought ) everlasting buildings.

But now these later ages are much more active and stirring : so that every ambitious man may finde so much businesse for the present, that he shall scarce have any leisure to trouble himself about the future. And therefore in all these respects , there is a great disproportion betwixt the incitements of those former and these latter times unto such magnificent attempts.

Again, as they differ much in their *motives* unto them, so likewise in the means of effecting them.

There was formerly more leisure and opportunity, both for the great men to undertake such works, and for the people to perfect them. Those past ages were more quiet and peaceable, the Princes rather wanting imployment, then being over-prett with it, and therefore were willing to make choice of such great designs, about which to busie themselves : whereas now the world is growne more politick, and therefore more trouble-

troublesome, every great man having other private and necessary businesse about which to imploy both his time and means. And so likewise for the common people, who then living more wildly without being confined to particular trades and professions, might be more easily collected about such famous employments; whereas now, if a Prince have any occasion for an Army, it is very hard for him to raise so great a multitude, as were usually imployed about these magnificent buildings. We read of 360000 men that were busied for twenty years in making one of the Egyptian Pyramids. And *Herodotus* tels us of 1000000 men who were as long in building another of them. About the carriage of one stone for *Amasis* the distance of twenty days journey, there was for three years together imployed 2000 chosen men, Governours, besides many other under labourers. 'Twas the opinion of \* *Josephus* and *Nazianzen*, that these Pyramids were built by *Joseph* for granaries against the years

Lib. 2.

\* *Antiq.*  
l. 2. c. 5.

years of famine. Others think that the brick made by the children of *Israel*, was imployed about the framing of them, because we read that the Tower of *Babel* did consist of brick or artificial stone, *Gen.* 11. 3. And if these were the labourers that were busied about them, 'tis no wonder though they were of so vast a magnitude ; for we read that the children of *Israel* at their coming out of *Ægypt*, were numbred to be six hundred thousand, and three thousand, and five hundred and fifty men, *Numb.* 1. 46. so many handfulls of earth would almost make a mountain, and therefore we may easily beleieve that so great a multitude in so long a space as their bondage lasted, for above four hundred years, might well enough accomplish such vast designs.

In the building of *Solomons* Temple, there were threescore and ten thousand that bare burdens, and fourscore thousand hewers in the mountains, *1 Kings* 5. 15.

The *Ephesian* Temple was built by  
all



all *Asia* joyning together, the 127 pillars were made by so many kings according to their severall successions, the whole work being not finished under the space of two hundred and fifteen yeers. Whereas the transplacing of that Obelisk at *Rome* by *Sixtus* the fift, (spoken of before) was done in some few days by five or six hundred men; and as the work was much lesse then many other recorded by Antiquity: so the means by which it was wrought, was yet far lesse in this respect then what is related of them.

2. The abundance of wealth, which was then ingrossed in the possession of some few particular persons, being now diffused amongst a far greater number. There is now a greater equality amongst mankind, and the flourishing of Arts and Sciences, hath so stirred up the sparks of mens natural nobility, and made them of such active and industrious spirits, as to free themselves in a great measure from that slavery, which those former and wilder



wilder Nations were subjected unto.

In building one of the Pyramids, there was expended for the maintenance of the labourers with Radish and Onyons, no lesse then eighteen hundred talents, which is reckoned to amount unto 1880000 crowns, or thereabouts. And considering the cheapnesse of these things in those times and places, so much money might go farther then a sum ten times greater could doe in the maintenance of so many now.

In *Solomons* Temple we know how the extraordinary riches of that King, the general flourishing of the whole State, and the liberality of the people did joyntly concur to the building of the Temple. *Pecuniarum copia & populi largitus, majora dictu conabatur*, (saith *Josephus*) The *Rhodian* Colossus is reported to have cost three hundred talents the making. And so were all those other famous monuments of proportionable expence.

*Pan-irollus* speaking of those Theaters that were erected at the charges  
of

De bell.  
Jud. l. 6.  
cap. 6.

of some private Romane Citizens, saith thus : *Nostro hoc saculo vel Rex satis haberet quod ageret adificio ejusmodi erigendo*; and a little after upon the like occasion, *Res mehercule miraculosa, qua nostris temporibus vix à potentissimo aliquo rege possit exhiberi.*

Deperd.  
Tit. 18.

3. Adde unto the two former considerations that exact *care* and indefatigable *industry* which they bestowed in the raising of those structures: These being the chief and onely designs on which many of them did imploy all their best thoughts and utmost endeavours. *Cleopes* an *Ægyptian* King is reported to have been so desirous to finish one of the *Pyramids*, that having spent all about it he was worth, or could possibly procure, he was forced at last to prostitute his own daughter for necessary maintenance. And we read of *Ramises* another King of *Ægypt*, how that he was so carefull to erect an *Obelisk*, about which he had imployed 20000 men, that when he feared lest through the negligence of the artificers, or weaknesse of the engine,

Plin l. 36.  
c. 9.

*Histor. Ind.*  
*l. 6. c. 14.*

gine, the stone might fall and break, he tyed his own son to the top of it, that so the care of his safety might make the workmen more circumspect in their businesse. And what strange matters may be effected by the meer diligence and labour of great multitudes, we may easily discern from the wilde Indians, who having not the art or advantage of Engines, did yet by their unwearied industry remove stones of an incredible greatnesse. *Acofta* relates that he himself measured one at *Tiaguanaco*, which was thirty eight foot long, eighteen broad, and six thick, and he affirms that in their stateliest ædifices, there were many other of much vaster magnitude.

From all which considerations it may appear, that the strangenesse of those ancient monuments above any that are now effected, does not necessarily infer any defect of art in these later ages. And I conceive, it were as easie to demonstrate the Mechanical Arts in these times to be so farre beyond the knowledge of former  
ages,

ages, that had we but the same means as the Ancients had, we might effect far greater matters then any they attempted, and that too in a shorter space, and with lesse labour.

## CAP. XII.

*Concerning the force of the Mechanick faculties, particularly the Ballance and Leaver. How they may be contrived to move the whole world, or any other conceivable weight.*

ALL these magnificent works of the Ancients before specified, are scarce considerable in respect of art, if we compare them with the famous speeches and acts of *Archimedes*: Of whom it is reported that he was frequently wont to say, how that he could move, *Datum pondus cum datâ potentiâ*, The greatest conceivable weight with the least conceivable power: and that if he did but know where to stand and fasten his instrument, he could move the world, all  
this



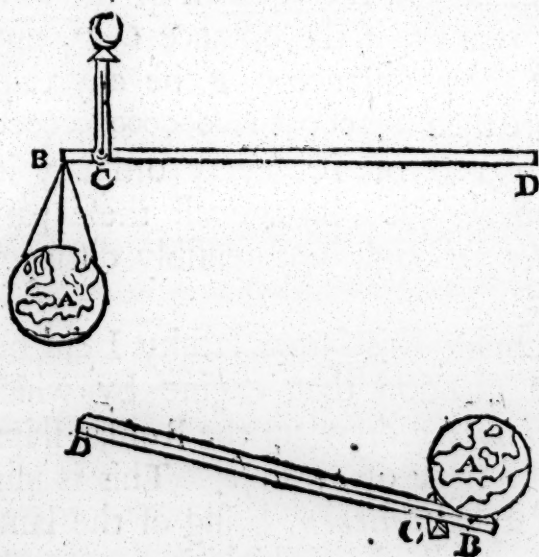
this great globe of sea and land ; which *promises*, though they were altogether above the vulgar apprehension or belief, yet because his *acts* were somewhat answerable thereunto, therefore the King of *Syracuse* did enact a law whereby every man was bound to believe, what ever *Archimedes* would affirm.

'Tis easie to demonstrate the Geometricall truth of those strange assertions, by examining them according to each of the forenamed *Mechanick* faculties, every one of which is of infinite power.

To begin with the two first of them, the Ballance and the Leaver, (which I here joyn together, because the proportions of both are wholly alike) 'tis certain, though there should bee the greatest imaginable weight, and the least imaginable power, (suppose the whole world, and the strength of one man or infant) yet if we conceive the same dis-proportion betwixt their severall distances in the former faculties from the fulciment or center of gravity,



vity, they would both equiponderate,  
 And if the distance of the power from  
 the center, in comparifon to the distance  
 of the weight, were but any thing  
 more then the heavinefs of the weight  
 is in refpect of the power, it may then  
 be evident from the former principles,  
 that the power would be of greater  
 force then the weight, and confequently  
 able to move it.



Thus if we fuppofe this great globe at *A*, to  
 G con-

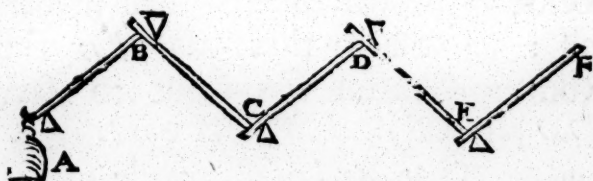


posts, the one fastned perpendicularly in the ground, the other being jointed on cross to the top of it. At the end he fastned a strong hook or grapple of iron, which being let over the wall to the river, he would thereby take hold of the ships, as they passed under; and afterwards by applying some weight, or perhaps the force of Screws to the other end, he would thereby lift them into the open air, where having swung them up and down till he had shaken out the men and goods that were in them, he would then dash the Vessels against the rocks, or drown them in their sudden fall: insomuch that *Marcellus* the Roman General was wont to say, *ἦ μὲν ναυσὶν αὐτῶ κυανίζεν ἐν θαλάττῃς Ἀρχιμήδης*, That *Archimedes* made use of his ships instead of Buckets, to draw water with.

*Plusarch.*  
in his life.

This faculty will be of the same force, not only when it is continued in one, but also when it is multiplied in divers instruments, as may be conceived in this other form, which I

do not mention, as if it could be serviceable for any motion ( since the space by which the weight would be moved, will be so little as not to fall under sense ) but onely for the better explication of this Mechanick principle, and for the right understanding of that force arising from multiplication in the other faculties, which do all depend upon this. The Wheel, and Pulley, and Screw, being but as so many Leavers of a circular form and motion, whose strength may therefore be continued to a greater space.



Imagine the weight *A*, to be an hundred thousand pounds, and the distance of that point, wherein every Leaver touches either the weight or one another from the point where they touch the prop, to be but one  
such



such part, whereof the remainder contains ten, then according to the former grounds 10000 at *B*, will equiponderate to *A*, which is 100000, so that the second Leaver hath but 10000 pounds to move. Now because this observes the same proportions with the other in the distances of its severall points, therefore 1000 pounds at *C*, will be of equall weight to the former. And the weight at *C*, being but as a thousand pound, that which is but as a hundred at *D*, will be answerable unto it; and so still in the same proportion, that which is but 10 at *E*, will be equall to 100 at *D*; and that which is but one pound at *F*, will also be equall to ten at *E*. Whence it is manifest, that 1 pound at *F*, is equall to 100000 at *A*; and the weight must alwayes be diminished in the same proportion as ten to one, because in the multiplication of these Leavers, the distance of the point, where the instrument touches the weight, from that where it touches the prop, is but as one such

part whereof the remainder contains ten. Bnt now if we imagine it to be as the thousandth part, then must the weight be diminished according to this proportion ; and then in the same multiplication of leavers, 1 l. will be equal to 1000 000 000 000 000 pounds : so that though we suppose the weight to be never so heavy, yet let the disproportion of distances be greater, or the Leavers more, and any little power may move it.

## CAP. XIII.

*Of the Wheel, by multiplication of which it is easie to move any imaginable weight.*

THE Wheel or *axis in peritrochio*, was before demonstrated to bee of equivalent force with the former faculties. If we conceive the same difference betwixt the Semidiameter of the wheels or spokes *AC*, and the Semidiameter of the axis *AB*, as there is betwixt the weight of the world, and

See the figure cap 6. pa. 38.

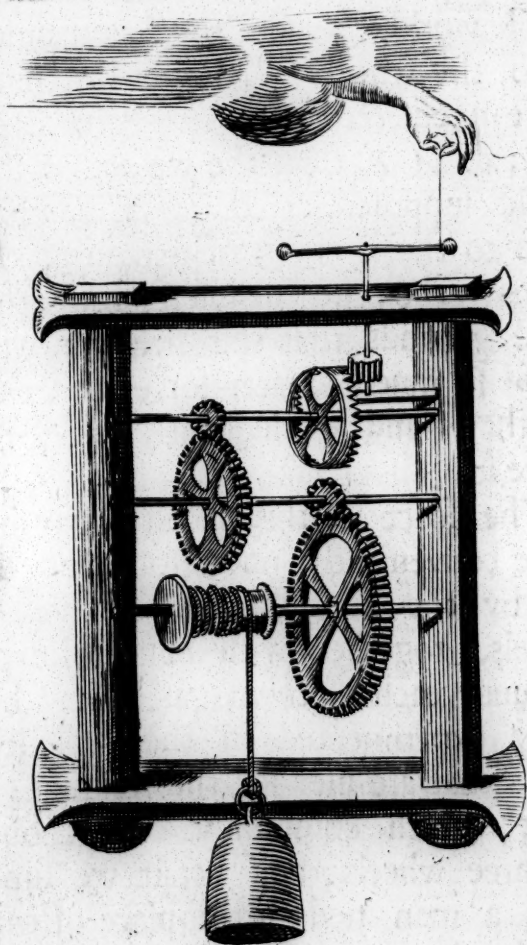
and the strength of a man, it may then be evident, that this strength of one man, by the help of such an instrument, will equiponderate to the weight of the whole world. And if the Semidiameter of the wheel *AC*, be but any thing more in respect of the Semidiameter of the axis *AB*, then the weight of the world supposed at *D*, is in comparison to the strength of a man at *C*; it may then be manifest from the same grounds that this strength will be of so much greater force then the weight, and consequently able to move it.

The force of this faculty may be more conveniently understood and used by the multiplication of severall wheels, together with nuts belonging unto each of them; as it may be easily experimented in the ordinary Jacks that are used for the roasting of meat, which commonly consist but of three wheels, and yet if we suppose a man tied in the place of the weight, it were easie by a single hair fastned unto the fly or ballance of the

An engine of many wheels is commonly called *Glossocorvus*.

How to pull a man above ground with a single hair.

Jack, to draw him up from the ground,  
as will be evident from this following  
figure.





Where suppose the length of the fly or ballance in comparison to the breadth of its axis, to be as 10 to one, and so for the three other wheels in respect of the nuts that belong unto them; (though this difference be oftentimes less, as we may well allow it to be) withall suppose the weight (or a man tyed in the place of it) to be a hundred pounds: I say according to this supposition, it is evident that the power at the ballance, which shall be equall to the weight, need be but as 1 to 10000. For the first axis is conceived to be but as the tenth part of its wheel, and therefore though the weight in it self be as 10000, yet unto a power that hath this advantage, it is but as 1000, and therefore this thousand unto the like power at the second wheel, will be but as 100, and this 100 at the third but as 10; and lastly, this ten at the ballance but as one. But the weight was before supposed to be 100, which to the first wheel will be but 10, to the second as one, to the third as a decimal,

mall, or one tenth, to the sails as one hundreth part : so that if the hair be but strong enough to lift  $\frac{1}{10000}$  that is, one ten thousandth part of a man, or (which is all one) one hundreth part of a pound, it may as well serve by the help of this instrument for the drawing of him up. And though there be not altogether so great a disproportion betwixt the severall parts of a Jack, (as in many perhaps there is not;) and though a man may be heavier then is here supposed, yet 'tis withall considerable that the strength of a hair is able to bear much more then the hundreth part of a pound.

*Comment.*  
*in Gen. c. 1.*  
*v. 10. art. 6.*  
*De viribus*  
*motricibus*  
*Theor. 16.*

Upon this ground *Mersennus* tells us out of *Solomon de Cavet*, that if there were an engine of 12 wheels, each of them with teeth, as also the axes or nuts that belong unto them, if the Diameter of these wheels were unto each *axis*, as a hundred to one: and if we suppose these wheels to be so placed, that the teeth of the one might take hold of the axis that belongs unto the next, and that the axis  
of

of the handle may turn the first wheel, and the weight be tyed unto the axis of the last, with such an engine as this, saith he, a child ( if he could stand any where without this earth ) might with much ease move it towards him.

For according to the former supposition, that this globe of sea and land, did contain as many hundred pounds, as it doth cubical feet, *viz.* 2400000000000000000000000, it may be evident that any strength, whose force is but equivalent to 3 pounds, will by such an engine bee able to move it.

Of this kinde was that engine so highly extolled by *Stevinus*, which he calls *Pancration*, or *Omnipotent*, preferring it before the inventions of *Archimedes*. It consisted of wheels and nuts, as that before specified is supposed. Hither also should be referred the force of racks, which serve for bending of the strongest bowes, as also that little pocket engine where-with a man may break or wrench open

*De statica  
proxi.*

*Ramelli  
Fig. 160.*

pen any dore, together with divers the like instruments in common use.

#### C A P. XIV.

*Concerning the infinite strength of Wheels, Pulleys, and Screws. That it is possible by the multiplication of these, to pull up any Oak by the roots with a hair, lift it up with a straw, or blow it up with ones breath, or to perform the greatest labour with the least power.*

FROM what hath been before delivered concerning the nature of the Pulley, it is easie to understand, how this faculty also may be proportioned betwixt any weight, and any power, as being likewise of infinite strength.

'Tis reported of *Archimedes*, that with an engine of Pulleyes, to which he applyed only his left hand, he lifted up \* 5000 bushels of corn at once, and drew a ship with all its lading

\*7000saith  
Zetres  
Chi. iad 2.  
Hist 35.



ding upon dry land. This engine Zetxes calls *Trispatum*, or *Trispastum*, which signifies onely a threefold Pulley; But herein he doth evidently mistake, for 'tis not possible that this alone should serve for the motion of so great a weight, because such an engine can but make a supsextuple, or at most a subseptuple proportion betwixt the weight and power, which is much too little, to reconcile the strength of a man unto so much heaviness. Therefore *Ubaldu*s doth more properly style it *Polyspaston*, or an instrument of many Pulleys: How many, were easie to find out, if we did exactly know the weight of those ancient measures; supposing them to be the same with our bushell in *England*, which contains 64 pintes or pounds, the whole would amount to 320000 pounds, half of which would be lightned by the help of one Pulley, three quarters by two Pulleys, and so onward, according to this subduple, subquadruple, and subsextuple proportion: So that if we conceive the strength of

*Præf. ad  
Mechan.*

of the left hand to be equivalent unto 20 or 40 pounds, it is easie to find out how many Pulleys are required to inable it for the motion of so great a weight.

*Comment.*  
*in Gen. c. 1.*  
*v 10. art. 6.*

*Præf. ad*  
*Mechan.*  
*Aristotle.*

Upon this ground *Mersennus* tells us, that any little child with an engine of an hundred double Pulleys, might easily move this great globe of earth, though it were much heavier then it is. And in reference to this kind of engine (saith *Monantholius*) are we to understand that assertion of *Archimedes* (as he more immediately intended it) concerning the possibility of moving the world.

The wedge was before demonstrated to be as a double Vectis or Leaver, and therefore it would be needless to explain particularly how this likewise may be contrived of infinite force.

The Screw is capable of multiplication, as well as any of the other faculties, and may perhaps be more serviceable for such great weights, then any of the rest. *Archimedes* his engine

engine of greatest strength, called *Charistion*, is by some thought to consist of these. *Axes habebat cum infinitis cochleis*. And that other engine of his called *Helix* ( mentioned by \* *Athenaus* ) wherewith he lifted *Hiero's* great ship into the sea, without any other help, is most likely to be framed of perpetuall screws, saith *Rivaltus*.)

Whence it may evidently appear, that each of these Mechanick faculties are of infinite power, and may be contrived proportionable unto any conceivable weight. And that no naturall strength is any way comparable unto these artificiall inventions.

'Tis reported of *Sampson*, that he could carry the gates of a city upon his shoulders, and that the strongest bonds were unto him but as flax burnt with fire, and yet his hair being shaved off, all his strength departed from him. We\* read of *Milo*, that he could carry an Oxe upon his back, and yet when he tried to tear an Oak asunder

*Stevin. de Static. prax. See Besson.*

\* *Deipnosophist. li 5. Oper. extier. Archimed.*

*Judg. 15.*

\* *A. Gel. Noft. An. l. 15. c. 16.*

der that was somewhat riven before, having drawn it to its utmost, it suddenly joined together again, catching his hands in the cleft, and so strongly manackled him, that he became a prey to the wilde beasts.

But now by these Mechanicall contrivances, it were easie to have made one of *Sampsons* hairs that was shaved off, to have been of more strength, then all of them when they were on. By the help of these arts it is possible ( as I shall demonstrate ) for any man to lift up the greatest Oak by the roots with a straw, to pull it up with a hair, or to blow it up with his breath.

Suppose the roots of an Oak to extend a thousand foot square, ( which is almost a quarter of a mile ) and forty foot deep, each cubicall foot being a hundred pound weight ; which though it be much beyond the extension of any tree, or the weight of the earth, the compass of the roots in the ground ( according to common opinion ) not extending further then the branches of it in the air, and the  
depth



depth of it not above ten foot, beyond which the greatest rain doth not penetrate (saith \* Seneca.) *Ego vinearum diligens fossor affirmo nullam pluviam esse tam magnam, quæ terram ultra decem pedes in altitudinem madefaciat.* And because the root must receive its nourishment from the help of showers, therefore it is probable that it doth not goe below them. So that (I say) though the proportions supposed doe much exceed the reall truth, yet it is considerable that some great overplus must be allowed for that labour which there will be in the forcible divulsion or separation of the parts of the earth which are continued.

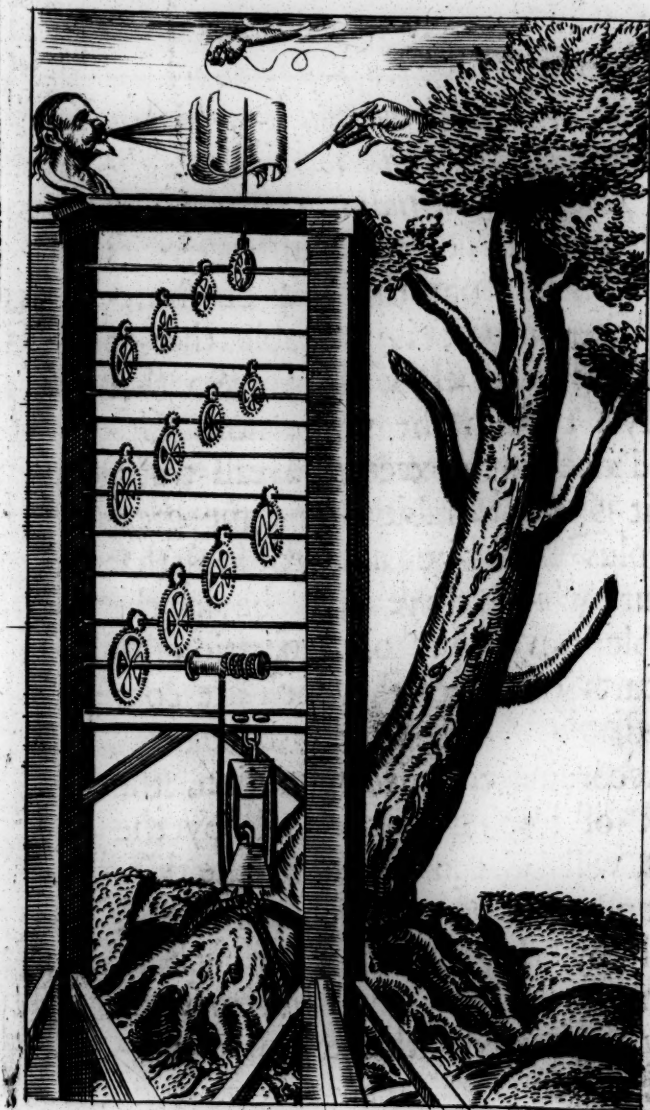
\* Nat. Qu.  
l. 3 c. 7.

According to this supposition, the work of forcing up the Oak by the roots will be equivalent to the lifting up of 4000000000 pound weight, which by the advantage of such an engine, as is here described, may be easily performed with the least conceivable power.

H

The

2



The whole force of this engine doth consist in two double Pulleys, twelve wheels, and a sail. One of these Pulleys at the bottome will diminish half of the weight, so that it shall be but as 2000000000, and the other Pulley will abate  $\frac{3}{4}$  three quarters of it : so that it shall be but as 1000000000. And because the beginning of the string being fastned unto the lower Pulley, makes the power to be in a subquintuple proportion unto the weight, therefore a power that shall be as 1000000000, that is, a subquadruple, will be so much stronger then the weight, and consequently able to move it. Now suppose the breadth of all the axes and nuts, to be unto the Diameters of the wheel as ten to one ; and it will then be evident, that to a power at the first wheel, the weight is but as 100000000. To the second as 10000000. To the third as 1000000. To the fourth as 100000. To the fifth as 10000. To the sixth as 1000. To the seventh as a 100. To the eighth

See chs. 7

as 10. To the ninth as 1. To the tenth as  $\frac{1}{10}$ , one decimall. To the eleventh as  $\frac{1}{100}$ . To the twelfth as  $\frac{1}{1000}$ . And the fails yet lesse. So that if the strength of the straw, or hair, or breath, be but equall to the weight of one thousandth part of a pound, it may be of sufficient force to pull up the Oak.

If in this engine we suppose the disproportion betwixt the wheelles and nuts, to be as an hundred to one, then it is very evident that the same strength of breath, or a hair, or a straw, would be able to move the whole world, as will be easily found by calculation. Let this great globe of sea and land bee imagined (as before) to weigh so many hundred pounds as it contains cubicall feet ; namely, 240000000000000000000000000000 pounds. This will bee to the first Pulley, 120000000000000000000000000000. To the second lesse the 600000000000000000000000000000. But for more easie and convenient reckoning, let it be supposed to be somewhat more, viz. 100000000000000000000000000000

This





Phys. I. 7.  
c. 3.

( *Pulsio.*  
*Tractio.*  
*Vectio.*  
*Vertigo.*

Thrusting, Drawing, Carrying, Turning. Unto some of which all these artificial operations must necessarily be reduced, the strength of any power being equally appliable unto all of them; So that there is no work impossible to these contrivances, but there may be as much acted by this art, as can be fancied by imagination.

### C A P. XV.

*Concerning the proportion of slownesse  
and swiftnesse in Mechanical motions.*

**H**AVING already discoursed concerning the *strength* of these Mechanical Faculties: it remains for the more perfect discovery of their natures, that we treat somewhat concerning those two differences of artificial motion:

Slow-

{ Slownesse,  
and  
{ Swiftnesse.

Without the right understanding of which, a man shall be exposed to many absurd mistakes, in attempting of those things, which are either in themselves impossible, or else not to be performed with such means as are applyed unto them. I may safely affirm, that many, if not most mistakes in these Mechanicall designs, doe arise from a mis-apprehension of that difference, which there will be betwixt the slownesse or swiftness of the weight and power, in comparison to the proportion of their severall strengths.

Hence it is, that so many engines invented for mines and water-works do so often fail in the performance of that for which they were intended, because the artificers many times doe forget to allow so much time for the working of their engine, as may be proportionable to the difference betwixt the weight and power that

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belong

belong unto them; whereas he that rightly understands the grounds of this art, may as easily find out the difference of space and time, required to the motion of the weight and power, as he may their different strengths; and not only tell how any power may move any weight, but also in what a space of *time* it may move it any space or *distance*.

If it were possible to contrive such an invention, whereby any conceivable weight may be moved by any conceivable power, both with the same quicknesse and speed (as it is in those things which are immediately stirred by the hand, without the help of any other instrument) the works of nature would be then too much subjected to the power of art : and men might be thereby encouraged (with the builders of *Babell*, or the rebell Gyants) to such bold designs as would not become a created being. And therefore the wisdom of providence hath so confined these humane arts, that what any invention hath



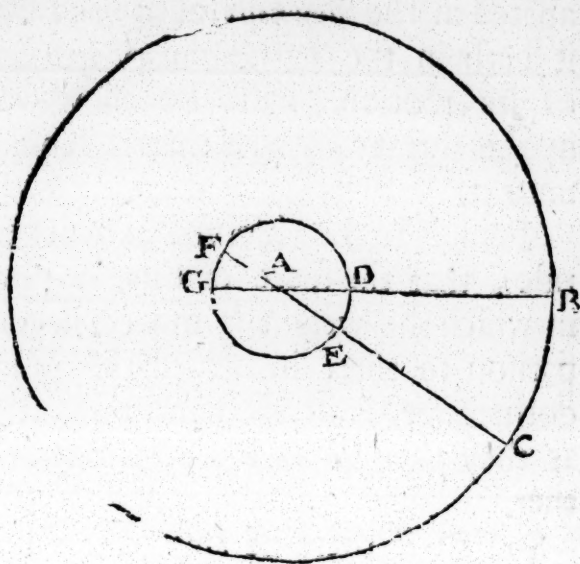
hath in the *strength* of its motion, is abated in the *slownesse* of it: and what it hath in the extraordinary *quickness* of its motion, must be allowed for in the great *strength* that is required unto it.

For it is to be observed as a general rule, that the space of time or place, in which the weight is moved, in comparison to that, in which the power doth move, is in the same proportion as they themselves are unto one another.

So that if there be any great difference betwixt the strength of the weight and the power, the same kind of difference will there be in the spaces of their motion.

To illustrate this by an example:

Let



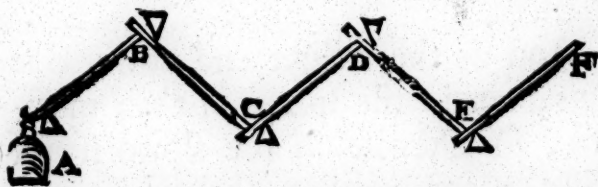
Let the line  $GAB$ , represent a balance or leaver, the weight being supposed at the point  $G$ , the fulcrum at  $A$ , and the power sustaining the weight at  $B$ . Suppose the point  $G$ , unto which the weight is fastned, to be elevated unto  $F$ , and the opposite point  $B$ , to be depressed unto  $C$ ; 'tis evident that the arch  $FG$ , or (which is all one)  $DE$ , doth shew the space of the weight, and the arch  $BC$ , the motion of the power. Now both

both these arches have the same proportion unto one another, as there is betwixt the weight and the power, or (which is all one) as there is betwixt their severall distances from the fulciment. Suppose  $AG$ . unto  $AB$ , to be as one unto four, it may then be evident that  $FG$ , or  $DE$ , will be in the same proportion unto  $BC$ . For as any two Semidiameters are unto one another, so are the severall circumferences described by them, as also any proportional parts of the same circumferences.

And as the weight and power doe thus differ in the spaces of their motions, so likewise in the slownesse of it; the one moving the whole distance  $BC$ , in the same time, wherein the other passes onely  $GF$ . So that the motion of the power from  $B$  to  $C$ , is four times swifter then that of the weight from  $G$  to  $F$ . And thus will it be, if we suppose the disproportions to be far greater, whether or no we conceive it, either by a continuation of the same instrument and fa-

faculty, as in the former example, or by a *multiplication* of divers, as in Pulleys, Wheels, &c. By how much the power is in it self lesse then the weight, by so much will the motion of the weight be slower, then that of the power.

To this purpose I shall briefly touch at one of the Diagrams expressed before in the twelfth Chapter, concerning the multiplication of Leavers,



In which, as each instrument doth diminish the weight according to a decuple proportion, so also do they diminish the *space* and *slownesse* of its motion. For if we should conceive the first Leaver *B*, to be depressed unto its lowest, suppose ten foot, yet the weight *A*, would not be raised



fed above one foot; but now the second Leaver at its utmost could move but a tenth part of the first, and the third Leaver but a tenth part of the second, and so of the rest. So that the last Leaver *F*, being depressed, will passe a *space* 100000 greater, and by a motion, 100000 swifter then the weight at *A*.

Thus are we to conceive of all the other faculties, wherein there is constantly the same disproportion betwixt the weight and power, in respect of the spaces and slownesse of their motions, as there is betwixt their severall gravities. If the power be unto the weight, but as one unto a hundred, then the space through which the weight moves, will be a hundred times lesse, and consequently the motion of the weight a hundred times slower than that of the power.

So that it is but a vain and impossible fancy for any one to think that he can move a great weight with a little power in a litle space; but in all these Mechanicall attempts, that advantage

vantage which is gotten in the strength of the motion, must be still allowed for in the slownesse of it.

Though these contrivances doe so extreemly increase the power, yet they doe proportionably protract the time. That which by such helps one man may do in a hundred dayes, may be done by the immediate strength of a hundred men in one day.

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C A P. XVI.

*That it is possible to contrive such an artificiall motion, as shall be of a slownesse proportionable to the swiftnesse of the heavens.*

**I**T were a pretty subtilty to enquire after, whether or no it be not possible to contrive such an artificiall motion, that should be in such a proportion flow, as the heavens are supposed to be swift.

For the exact resolution of which, it would be requisite that we should first pitch upon some *medium*, or indiffe-

different motion, by the distance from which, we may judge of the proportions on either side, whether slownesse or swiftnesse. Now because there is not any such *naturall medium*, which may be absolutely styled an indifferent motion, but that the swiftnes and slownesse of every thing, is still proportioned either to the quantity of bodies, in which they are, or some other particular end for which they are designed; therefore we must take liberty to suppose such a motion, and this we may conceive to be about 1000 paces, or a mile in an hour.

The starry heaven, or 8<sup>h</sup>. sphere is thought to move 42398437 miles in the same space: So that if it may be demonstrated that it is possible to contrive such a motion, which going on in a constant direct course, shall passe but the 42398437 part of a mile in an hower, it will then be evident, that an artificial motion may be slow, in the same proportion as the heavens are swift.

Now

Now it was before manifested that according to the difference betwixt the weight and power, so will the difference be betwixt the slownesse or swiftnesse of their motions; whence it will follow, that in such an engine, wherein the weight shall bee 42398437 pounds, and the power that doth equiponderate it, but the 42398437 part of a pound ( which is easie to contrive ) in this engine the power being supposed to move with such a swiftnesse, as may be answerable to a mile an hower, the weight will passe but the 42398437 part of a mile in the same space, and so consequently will be proportionably slow unto the swiftnesse of the heavens.

Preface to  
Euclid.

It is related by our Country-man *I. Dee*, that he and *Cardan* being both together in their travels, they did see an instrument which was at first sold for 20 talents of gold, wherein there was one wheel, which constantly moving round amongst the rest, did not finish one revolution under the space of seven thousand years.

But



But if we farther consider such an instrument of wheels as was mentioned before in the 14 chapter, with which the whole world might bee easily moved, we shall then find that the motion of the weight by that, must be much more slow, than the heavens are swift. For though we suppose (saith *Stevinus*) the handle of such an engine with 12 wheels to be turned about 4000 times in an hour, (which is as often as a mans pulse doth beat) yet in ten years space the weight by this would not be moved above  $\frac{10^{12}}{2400}$  ooooooooooooooooooooo parts of one foot, which is nothing near so much as a hairs breadth. And it could not passe an inch in 1000000 years, saith *Mersennus*.

*De stat.  
pract.*

*Phænom.  
Mechan  
prop. 11.*

The truth of which we may more easily conceive, if we consider the frame and manner of this 12 wheeld engine. Suppose that in each axis or nut, there were ten teeth, and on each wheel a thousand: then the sails of this engine must be turned a hundred times, before the first wheel, (recko-

I

ning

ning downward) could be moved round once, and ten thousand times before the second wheel can finish one revolution, and so through the 12 wheels, according to this multiplyed proportion.

So that besides the wonder which there is in the force of these Mechanicall motions, the extream slownesse of them is no lesse admirable. If a man consider that a body should remain in such a constant direct motion, that there could not be one minute of time, wherein it did not rid some space, and passe on further, and yet that this body in many years together, should not move so far as a hairs breadth.

Which notwithstanding may evidently appear from the former instance. For since it is a naturall principle, that there can be no penetration of bodies, and since it is supposed, that each of the parts in this engine doe touch one another in their superficies, therefore it must necessarily follow, that the weight does begin  
and

and continue to move with the power : and ( however it is insensible ) yet it is certain there must be such a motion so extreamly slow, as is here specified. So full is this art of rare and incredible subtilties.

I know it is the assertion of *Cardan*, *Motus valde tardi, necessario quietes habent intermedias*. Extream flow motions have necessarily some intermediate stops and rests : But this is onely said, not proved, and he speaks it from sensible experiments, which in this case are fallible. Our senses being very incompetent judges of the severall proportions, whether greatnesse or littlenesse, slownesse or swiftnesse, which there may be amongst things in nature. For ought we know, there may be some *Organicall* bodies, as much lesse then ours, as the earth is bigger. We see what strange discoveries of extream minute bodies, (aslice, wheal-worms, mites, and the like) are made by the *Microscope*, wherein their severall parts (which are altogether invisible to the

*De varietate rerum*  
l. 9. c. 47.

bare eye ) will distinctly appear: and perhaps there may be other insects that live upon them as they doe upon us. 'Tis certain that our senses are extreamly disproportioned for comprehending the whole compasse and latitude of things. And because there may be such difference in the *motion* as well as in the *magnitude* of bodies; therefore, though such extream slownesse may seem altogether impossible to sense and common apprehension, yet this can be no sufficient argument against the reality of it.

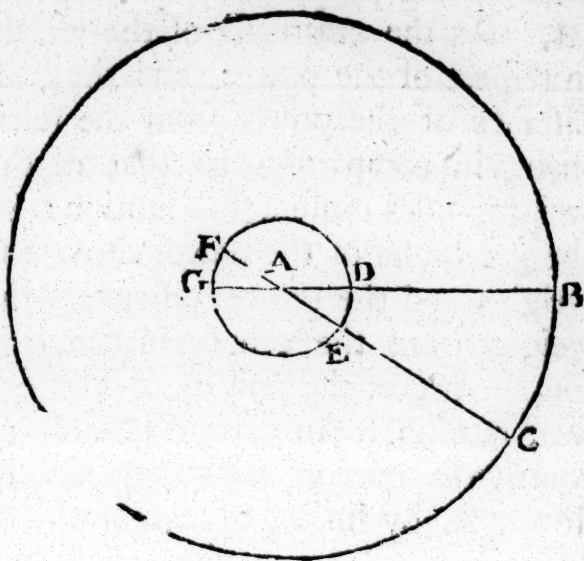
## CAP. XVII.

*Of swiftnesse, how it may be increased to any kind of proportion. Concerning the great force of Archimedes his Engines. Of the Ballista.*

BY that which hath been already explained concerning the slownesse of motion, we may the better understand the nature of swiftnesse, both of them ( as is the nature of opposites



sites) being produced by contrary causes. As the greatnesse of the weight in respect of the power, and the great distance of the power from the fulciment, in comparison to that of the weight, does cause a slow motion: So the greatnesse of the power above the weight, and the greater distance of the weight from the center, in comparison to that of the power, does cause a swift motion. And as it is possible to contrive a motion unto any kind of slownesse, by finding out an answerable disproportion betwixt the weight and power: so likewise unto any kind of swiftnesse. For so much as the weight does exceed the power, by so much will the motion of the weight be slower, and so much as the power does exceed the weight, by so much will the motion of the weight be swifter.



In the Diagram set down before, if we suppose *F*, to be the place of the power, and *C* of the weight, the point *A*, being the fulciment or center, then in the same space of time, wherein the power does move from *F*, to *G*, the weight will passe from *C*, to *B*. These distances having the same disproportion unto one another, as there is betwixt *AF*, and *AC*, which is supposed to be quadruple. So that in this example, the weight will move  
four

four times swifter then the power. And according as the power does exceed the weight in any greater disproportion, so will the swiftnesse of the weight be augmented.

Hence may we conceive the reason of that great force which there is in Slings, which have so much a greater swiftnesse, than a stone thrown from the hand, by how much the end of the Sling is farther off from the shoulder-joynt, which is the center of motion. The sacred history concerning *Dauids* victory over *Goliath*, may sufficiently evidence the force of these. *Vegetius* relates that it was usuall this way to strike a man dead, and beat the soul out of his body, without so much as breaking his armour or fetching blood. *Membris integris lethale tamen vulnus important, & sine invidia sanguinis, hostis lapidis ictu intreat.*

In the use of these, many of the Ancients have been of very exquisite and admirable skill. We read of seven hundred *Benjamites* left-handed, that could

I 4

sling

1 Sam. 17.  
49.  
L pñus Po-  
lior l. 4.  
Dialog. 2.

Judges 20.  
16.

Στο τὸ  
βαλλειν.  
Diodor. Si-  
cul. Bibli-  
oth. l. 5.  
L Florus  
Hist. l. 3.  
cap. 8.  
Ior Boemus  
Aubanus de  
moribus  
gentium  
l. 3. c. 26.

<sup>a</sup> Histor. l. 4.  
<sup>b</sup> Histor.  
Chilias 2.  
bistor. 35.  
<sup>c</sup> Li. 2. c. 7.  
<sup>d</sup> Marcel-  
lus.  
<sup>e</sup> Histor.  
l. 24.

sling a stone at a hairs breadth, and not misse. And there is the like storied of a whole Nation amongst the Indians, who from their excellency in this art were styled *Baleares*. They were so strict in teaching this art unto their young ones *Ut cibum puer à matre non accipit, nisi quem ipsa monstrante percussit*, That the mother would not give any meat to her child, till (being set at some distance) he could hit it with slinging.

For the farther illustration of this subject, concerning the *swiftnesse* of motion, I shall briefly specifie some particulars concerning the engines of War used by the Ancients. Amongst these, the most famous and admirable were those invented by *Archimedes*, by which he did perform such strange exploits, as (were they not related by so many and such judicious Authours) would scarce seem, credible even to these more learned ages. The acts of that famous Engineer, are largely set down by <sup>a</sup> Polybius, <sup>b</sup> Tzetzes, <sup>c</sup> Proclus, <sup>d</sup> Plutarch, <sup>e</sup> Li-



vy, and divers others. From the first of whom alone, we may have sufficient evidence for the truth of those relations. For besides that he is an Authour noted to be very grave and serious in his discourse; and does solemnly promise in one place that he will relate nothing, but what either he himself was an eye-witnesse of, or else what he had received from those that were so; I say, besides all this, it is considerable, that he himself was born not above thirty years after the Siege of *Syracuse*. And afterwards having occasion to tarry some weeks in that City, when he travelled with *Scipio*, he might there perhaps see those engines himself, or at least take his information from such as were eye-witnesses of their force: So that there can be no colourable pretence for any one to distrust the particulars related of them.

*Histor. l. 4.  
juxta initium.*

In brief, the sum of their reports is this: When the Romane forces under the conduct of *Marcellus*, had laid siege unto that famous City, (of which

which both by their former successes, and their present strength, they could not chuse but promise themselves a speedy victory ; ) yet the arts of this one Mathematician, notwithstanding all their policies and resolutions, did still beat them back to their great disadvantage. Whether they were neer the wall or farther from it, they were still exposed to the force of his engines, *ὃς μακρὰν ἀφ' ὧντας, καὶ συνίσχυς ὄντας, ἔμόνον ἀπράκτους παρυσκιάζει πρὸς τὰς ἰδίας ἐπιβολὰς, ἀλλὰ καὶ διέφθερε τὰς πλείους αὐτῶν.* From the multitude of those stones and arrowes, which he shot against them, was he styled *ἐκατόγχειρ*, or *Briareus*. Those defensive engines that were made by the Romanes in the form of Pent-houses for to cover the assailants from the weapons of the besieged, these would he presently batter in pieces with great stones and blocks. Those high towers erected in some of the ships, out of which the Romans might more conveniently fight with the defendants on the wall, these also were  
so

Cal: Rhod:

Ant: leff:

l. 2. c. 16.

Pluteus

Testudo.

so broken by his engines, that no Cannon or other instrument of Gunpowder, (saith a learned man) had they been then in use, could have done greater mischief. In brief, he did so molest them with his frequent and prodigious batteries, that the common soldiers were utterly discouraged from any hopes of successe.

Sir Walt:  
Raleigh hi-  
stor. l. 5. c. 3  
§ 16.

What was the particular frame and manner of these engines cannot certainly be determined, but to contrive such as may perform the like strange effects, were not very difficult to any one who is thoroughly versed in the grounds of this art. Though perhaps those of *Archimedes* in respect of divers circumstances, were much more exact and proper for the purposes to which they were intended, then the invention of others could be; He himself being so extraordinarily subtil and ingenious above the common sort of men.

’Tis probable that the generall kind of these engines, were the same vvith those that vvere used afterwards

wards amongst the Romanes and other Nations. These were commonly divided into two sorts: styled

*{ Ballista.*

*{ Catapulta.*

Both vvhich names are sometimes used promiscuously; but according to their propriety † *Ballista* does signifie an engine for the shooting of stones, and *Catapulta* for darts or arrowes.

The former of these was fitted either to carry divers lesser stones, or else one greatest one. Some of these engines made for great stones, have been proportioned to so vast and immense a weight, as may seem almost incredible: which occasioned that in *Lucan*,

*Vil. Nau-  
daum de  
Stud. Mi-  
lit. v. l. 2.*

† ὁποῦ τὸ  
βέβλην,  
called also  
λιθόβολος.  
πετρόβο-  
λος. *Fun-  
dibulus.*

*Petraria.*

*Lib. 3.*

*At saxum quoties ingenti verberis ictu  
Excutitur, qualis rupes quam vertice montis  
Abscidit impulsu ventorum adjuncta vetustas,  
Frangit cuncta ruēs; nec tantū corpora pressa  
Exanimat, totos cum sanguine dissipat artus.*

With these, they could easily batter down the walls and Towers of any Fort: So *Ovid*.

*Quam*



*Quam grave ballista mœnia pulsat  
onus.*

And Statius--- *Quo turbine bellica quon-  
dam*

*Librati saliunt portarum in claustra  
molares.*

The stones that were cast from these, were of any form, *Enormes & sepulchrales*, Milstones or Tombe-stones. Sometimes for the farther annoyance and terror of any besieged place, they would by these throw into it dead bodies, either of men or horses, and sometimes only parts of them as mens heads.

*Athenaus* mentions one of these *Ballista* that was proportioned unto a stone of three talents weight, each talent being 120 pounds (saith *Vitruvius*.) so that the whole will amount to 360 pounds. But it is storied of *Archimedes*, that he cast a stone into one of *Marcellus* his ships, which was found to weigh ten talents. There is some difference amongst \* Authors, concerning what kind of talent this should be understood, but it is certain that

*Lipsius Po-  
liorcer. l. 3.  
Dial. 3.*

*Deipno-  
soph. l. 5.*

*Archit. l.  
10. c. ult.  
λίθον δε-  
κατάλαν-  
τον.  
Plut. Mar-  
cell.*

\* *Dav. Ri-  
vultus Cō-  
men in Ar-  
chim. Oper.  
Ext.*

*Naudaus  
de studio.  
Milii. l. 2.*

*De stud.  
Milii. l. 2.*

that in *Plutarchs* time, (from whom we have this relation) one talent did amount to 120 pounds (saith *Swidas* :) according to which account, the stone it self was of no lesse then twelve hundred pound weight. A weapon (one would think) big enough for those rebell Gyants that fought against the gods. Now the greatest Cannon in use, does not carry above 64 pound weight, which is far short of the strength in these Mathematicall contrivances. Amongst the Turks indeed, there have been sometimes used such powder instruments, as may equall the force of those invented by *Archimedes*. *Gab. Naudaus* tells us of one bullet shot from them at the siege of *Constantinople*, which was of above 1200 pound weight; This he affirms from the relation of an Archbishop, who was then present and did see it; the piece could not be drawn by lesse then a hundred and fifty yoke of oxen, which might almost have served to draw away the Town it self. But though there hath been perhaps some one

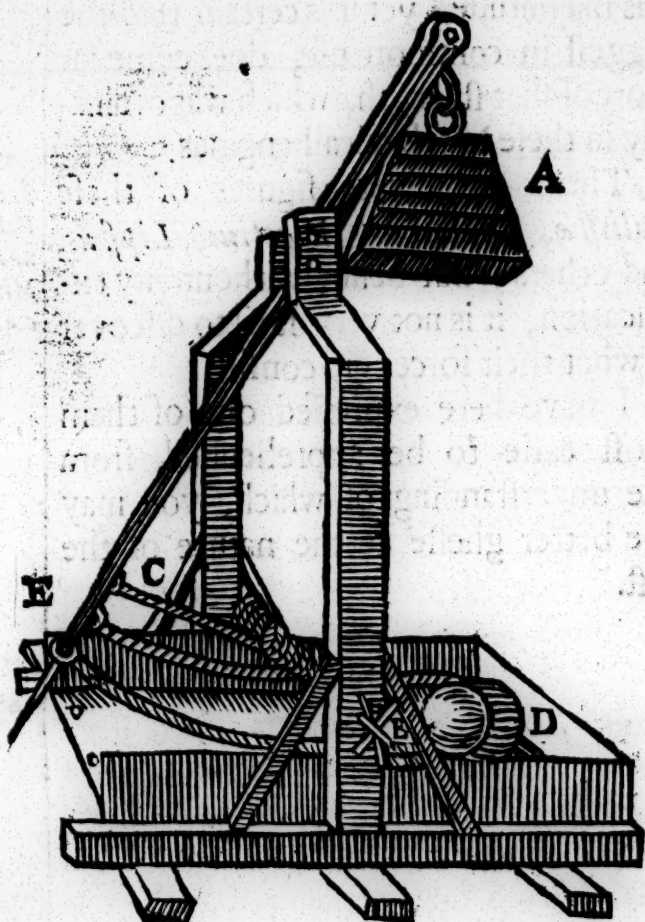
one or two Cannons of such a prodigious magnitude, yet it is certain that the biggest in common use, does come far short of that strength, which was ordinarily in these Mechanicall engines.

There are divers figures of these *Ballista*, set out by *Vigetius*, *Lipsius*, and others; but being without any explication, it is not very facile to discover in what their forces did consist.

I have here expressed one of them most easie to be apprehended, from the understanding of which, you may the better ghesse at the nature of the rest.

See Rob:  
*Valturi-*  
*us de re*  
*Milit.* l. 10.  
c. 4.

That



That great box or cavity at *A*, is  
supposed to be full of some heavy  
weight, and is forced up by the tur-  
ning



ning of the axis and spokes *B C*. The stone or bullet to be discharged being in a kind of sling at *D*, which when the greater weight *A*, descends, will be violently whirled upwards, till that end of the sling at *E*, coming to the top will flye off, and discharge the stone as the skilfull Artist should direct it.

## CAP. XVIII.

*Concerning the Catapulta, or Engines for Arrowes.*

**T**He other kind of engine was called *Catapulta*, *κατὰ πέλτης*, which signifies a spear or dart, because it was used for the shooting of such weapons: some of these were proportioned unto spears of twelve cubits long; they did carry with so great a force, *ut interdum nimio ardore scintillant*, (saith *Ammianus*) that the weapons discharged from them were sometimes (if you can believe it) set on fire by the swiftnesse of their motion.

In Greek  
*κατὰ πέλ-  
της*  
*Athenaus.*  
*Deipnos.*  
*l. 5.*

*Lib. 23.*

*Lipsius Po-  
liorces. l. 3*  
*Dial. 2.*

K

The

Diod Sicul.  
Biblioth.

l. 14.

Sardus de  
Invent. Re-  
rum. l. 2.

2 Cl ron.  
26. 15.

Sir Fran.  
Bacon Nat.  
Hist Exp.  
704.

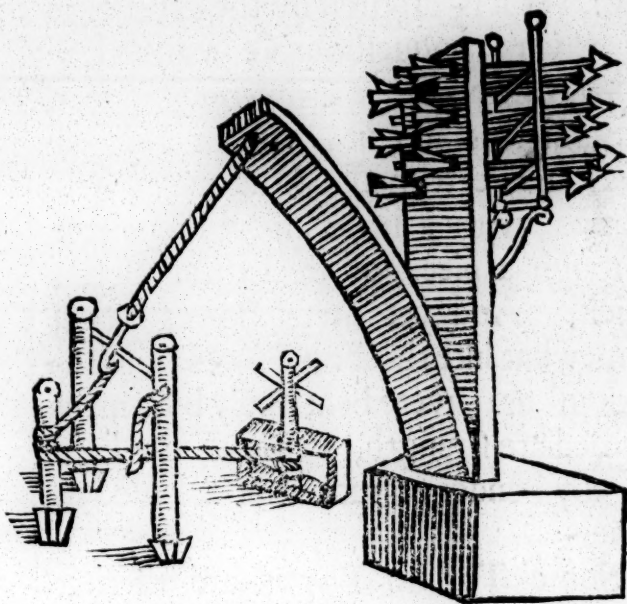
The first invention of these is commonly ascribed to *Dionysius* the younger, who is said to have made them amongst his other preparations against *Carthage*. But we have good reason to think them of more ancient use, because we read in Scripture that *Uzziah* made in *Jerusalem* engines invented by cunning men to shoot arrows and great stones withall: though it is likely these inventions were much bettered by the experience of after ages.

The usual form of these *Catapultæ*, was much after the manner of great Bowes placed on Carriages, and wound up by the strength of severall persons. And from that great force which we find in lesser Bowes, we may easily ghesse at the greater power of these other engines. 'Tis related of the Turkish Bow, that it can strike an arrow through a peece of steel or brasse two inches thick, and being headed only with wood, it pierces Timber of eight inches. Which though it may seem incredible,

ble, yet it is attested by the experience of divers unquestionable vvitnesses: *Barclay* in his *Icon animorum*, a man of sufficient credit, affirms that he vvas an eye vvitness, how one of these Bowes vvith a little arrow did pierce through a piece of steel three fingers thick. And yet these Bowes being somewhat like the long Bowes in use amongst us, vvere bent onely by a mans immediate strength, vvithout the help of any bender or rack that are used to others.

Some Turkish Bowes are of that strength, as to pierce a plank of six inches in thickenesse, (I speak vvhat I have seen) saith *M. Jo: Greaves* in his *Pyramodographia*. Hovv much greater force then may vve conceive to be impressed by the *Catapulta*?

These vvere sometimes framed for the discharging of two or three arrowes together, so that each of them might bee directed unto a severall aim. But it were as easie to contrive them after the like manner for the carriage of twenty arrowes, or more, as in this figure.



Who was  
therefore  
styled *Poliorcetes*.

This kind  
of Turret  
was first  
used at the  
siege of  
*Cyprus*, and  
is thus de-  
scribed by  
*Diodorus*  
*Siculus* Bib-  
lioth. L. 20.

Both these kinds of engines when they were used at the siege of any City, were commonly carried in a great wooden Turret (first invented by \* *Demetrius*.) It was driven upon four wheels at the bottome, each of its sides being forty five cubits, its height ninety. The whole was divided in nine severall partitions, every one of which did contain divers engines for battery: from its use in the battering and taking of Cities it is styled



stiled by the name of *Helepolis*.

He that would be informed in the nature of Bows, let him consult *Mersennus De Ballistica & Acontismologia*, where there are divers subtle inquiries and demonstrations, concerning the strength required, to the bending of them to any distance. The force they have in the discharge according to several bents, the strength required to be in the string of them, the several proportions of swiftnesse and distance in an arrow shot vertically, or horizontally, or transversally.

Those strange effects of the Turkish Bow (mentioned before) so much exceeding the force of others, which yet require far greater strength for the bending of them, may probably be ascribed either to the naturall cause of *attraction by similitude of substance* (as the Lord *Bacon* conjectures.)

For in these experiments the head of the arrow should be of the same substance (whether steel or wood) with that which it pierces : Or else to that *just proportion* betwixt the

weight of the arrow, and the strength of the bow, which must needs much conduce to the force of it, and may perhaps be more exactly discovered in these, then it is commonly in others.

---

C A P. XIX.

*A comparison betwixt these ancient engines, and the Gun-powder instruments now in use.*

**I**T shall not be altogether impertinent to inquire somewhat concerning the advantages and disadvantages betwixt those Military offensive engines, used amongst the Ancients, and those of these later ages.

In which inquiry there are two particulars to be chiefly examined :

1. The force of these several contrivances, or the utmost that may be done by them.
  2. Their price, or the greatnesse of the charges required unto them.
1. As for the force of these ancient

ent inventions, it may sufficiently appear from those many credible relations mentioned before; to which may be added that in *Josephus*, which he sets down from his own eye-sight, being himself a chief Captain at the siege of *Jotapata*, where these events happened. He tels us that besides the multitude of persons, who were slain by these Romane Engines, being not able to avoid their force, by reason they were placed so far off, and out of sight; besides this, they did also carry such great stones, with so great a violence, that they did therewith batter down their walls and Towers. A great bellied woman walking about the City in the day time, had her child struck out of her wombe, and carried half a furlong from her. A soldier standing by his Captain *Josephus*, on the wall, had h's head struck off by another stone sent from these Romane Engines, and his brains carried three furlongs off.

To this purpose *Cardan* relates out of *Ammianus Marcellinus*. Tanto

*De bello  
Judaico. l.  
3. c. 9.*

*De variet.  
l. 12. c. 58.*

*impetu fertur lapis ut uno viso lapide  
quamvis intacti barbari fuerint ab eo,  
desisterunt à pugna & abierunt.* Many  
forain people being so amazed at the  
strange force of these Engines, that  
they durst not contest with those who  
were masters of such inventions. 'Tis  
frequently asserted, that bullets have  
been melted in the air, by that extre-  
mity of violent motion imprest from  
these slings.

*Fundaque contorto transverberat aëra  
plumbo,*

*Et mediis liquidæ glandes in nubibus  
errant.*

So *Lucan*, speaking of the same En-  
gines.

*Inde faces & saxa volant, spatioque  
solutæ*

*Aëris & calidæ liquefactæ pondere  
glandes.*

Which relations, though they may  
seem somewhat poetick and impro-  
bable, yet *Aristotle* himself (*De cælo*  
*lib. 2. c. 7.*) doth suppose them as un-  
questionable. From whence it may  
be inferred, that the force of these En-  
gines



gines does rather exceed then come short of our Gun-powder inventions.

Add to this that opinion of a learned man (which I cited before) that *Archimedes* in the siege of *Syracuse*, did more mischief with his Engines, then could have been wrought by any Cannons, had they been then in use.

In this perhaps there may be some disadvantage, because these Mathematical Engines cannot be so easily and speedily wound up, and so certainly levelled as the other may.

2. As for the price or charges of both these, it may be considered under three particulars:

1. Their making.
2. Their carriage or conveyance.
3. Their charge and discharging.

In all which respects, the Cannons now in use, are of much greater cost then these other inventions.

1. The making or price of these Gun-powder instruments is extreamly expensive, as may be easily judged by the weight of their materials. A whole Cannon

*Sir Walt.  
Raleigh  
Hist. l. 5.  
c. 3. §. 16.  
See Lipsius  
de militia  
Romanâ.  
l. 5.*

Cannon weighing commonly 8000 l. a half Cannon 5000, a Culverin 4500, a Demiculverin 3000 ; which whether it be in iron or brasse, must needs be very costly, only for the matter of them; besides the farther charges required for the form and making of them, which in the whole must needs amount to severall hundred pounds. Whereas these Mathematicall inventions consisting chiefly of Timber, and cords, may be much more cheaply made ; The severall degrees of them which shall answer in proportion to the strength of those other, being at the least ten times cheaper; that is, ten Engines that shall be of equall force either to a Cannon or Demicannon, Culverin, or Demiculverin, may be framed at the same price that one of these will amount to : So that in this respect there is a great inequality.

2. As for their carriage or conveyance ; a whole Cannon does require at the least 90 men, or 16 horses, for the draught of it ; a half Cannon 56 men,

men, or 9 horses; a Culverin 50. men, or 8. horses; a Demiculverin 36 men, or 7 horses; Supposing the way to be hard and plain, in which notwithstanding the motion will be very slow. But if the passage prove rising and steep, or rotten and dirty, then they will require a much greater strength and charge for the conveyance of them. Whereas these other inventions are in themselves more light (if there be occasion for the draught of them) being easily taken asunder into several parts. And besides, their materials are to be found every where, so that they need not be carried up and down at all, but may be easily made in the place where they are to be used.

3. The materials required to the charging of these Gun-powder instruments are very costly. A whole Cannon requiring for every charge 40 pounds of powder, and a bullet of 64 pounds; a half Cannon 18 pounds of powder, and a bullet of 24 pounds; a Culverin 16. pounds of powder, and

a bullet of 19 pounds; a Demi-culverin 9 pounds of powder, and a bullet of 12 pounds : whereas those other Engines may be charged only with stones, or (which may serve for terror) with dead bodies, or any such materials as every place will afford without any cost.

So then, put all these together : If it be so that those ancient inventions did not come short of these other in regard of force, and if they doe so much excell them in divers other respects ; It should seem then, that they are much more commodious, then these later inventions, and should be preferred before them. But this enquiry cannot be fully determined without particular experience of both.

C A P.



## CAP. XX.

*That it is possible to contrive such an artificiall motion, as may be equally swift with the supposed motion of the heavens.*

FOR the conclusion of this Discourse, I shall briefly examine (as before concerning slownesse) whether it be possible to contrive such an artificiall motion, as may be equall unto the supposed swiftnesse of the heavens. This question hath been formerly proposed and answered by *Cardan*, where he applies it unto the swiftnesse of the moons orb; but that orb being the lowest of all, and consequently of a dull and sluggish motion, in comparison to the rest; therefore it will perhaps be more convenient to understand the question concerning the eighth sphere or starry heaven.

For the true resolution of this, it should be first observed, that a materiall substance is altogether incapable

*De Variet.  
Rerum l. 9.  
c. 47.*

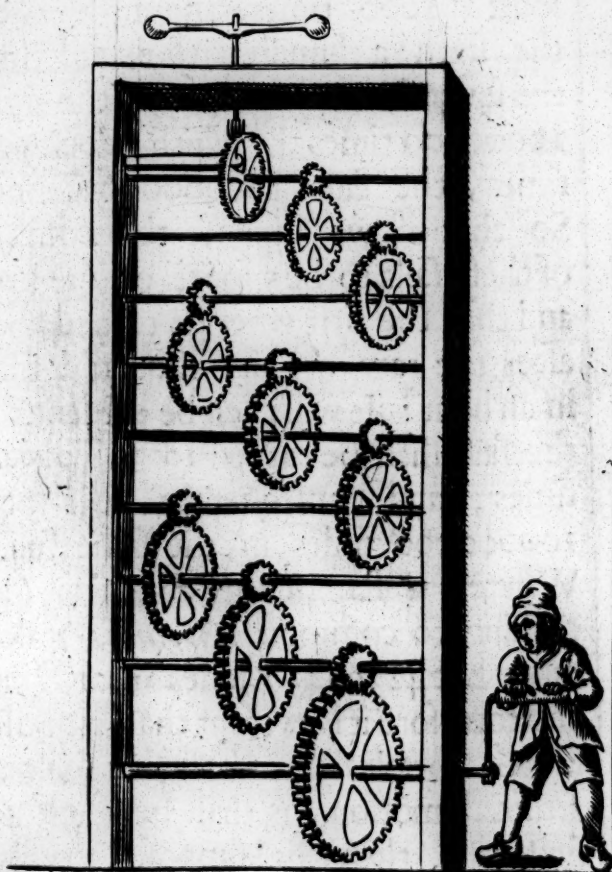
The earth  
a planet,  
prop. 9.

ble of so great a celerity, as is usually ascribed to the celestiaall orbs. (as I have proved elsewhere) And therefore the quære is not to be understood for any reall and experimentall, but onely notionall, and Geometricall contrivance.

Now that the swiftnesse of motion may be thus increased, according to any conceivable proportion, will be manifest from what hath been formerly delivered, concerning the grounds and nature of slownesse and swiftnesse. For according as we shall suppose the power to exceed the weight: so may the motion of the weight be swifter then that of the power.

But to answer more particularly: Let us imagine every wheel in this following figure to have an hundred teeth in it, and every nut ten:

It



It may then be evident, that one revolution of the first wheel, will turn the nut, and consequently the second wheel on the same axis ten times, the third


third wheel a hundred times, the fourth 1000 times, the fifth 10000 the sixth a hundred thousand times, the seventh 1000000 times, the eighth 10000000 times the ninth 100000000 times, the sails 1000000000 times : So that if we suppose the compasse of these sails to be 5 foot, or one pace : and that the first wheel is turned about after the rate of one thousand times in an hour : It will then be evident, that the sails shall be turned 1000000000000 times, and consequently shall passe 100000000 miles in the same space. Whereas a star in the *Æquator* ( according to common *Hypothesis* ) does move but 42398437 miles in an hour, and therefore it is evident that 'tis possible Geometrically to contrive such an artificiall motion, as shall be of greater swiftnesse, then the supposed revolutions of the heavens.



D Æ D A L U S,  
OR,  
M C H A N I C A L L  
Motions.

C H A P. I.

*The divers kinds of Automata, or Self-movers. Of Mills, and the contrivance of severall motions by rarified air. A brief digression concerning wind-guns.*

 Amongst the variety of artificiall motions, those are of most use and pleasure, in which, by the application of some continued strength, there is bestowed a regular and lasting motion.

These we call the *αὐτόματα*, or *self-movers*: which name in its utmost latitude, is sometimes ascribed unto those motions, that are contrived from the strength of living creatures, as Chariots, Carts, &c. But in its strictnesse and propriety, it is onely applicable unto such inventions, wherein the motion is caused either by something that belongs unto its own frame, or  
L else

else by some external inanimate agent.

Whence these *αὐτόματα* are easily distinguishable into two sorts:

1. Those that are moved by something which is extrinsecall unto their own frame, as Mills by water or wind.

2. Those that receive their motion from some thing that does belong to the frame it self, as clocks, watches, by weights, springs, or the like.

Of both which sorts, there have been many excellent inventions: In the recitall of them, I shall insist chiefly on such as are most eminent for their rarity and subtilty.

Amongst the *αὐτόματα* that receive their motion from some externall agent, those of more common use are Mills.

And first, the Water-mills, which are thought to be before the other, though neither the first Author, nor so much as the time wherein they were invented is fully known. And therefore *Polydor Virgil* refers them amongst other fatherlesse inventions. *Pliny* indeed doth mention them, as being commonly used in his time: and yet others

*De invent.  
Rerum, l. 3.  
c. 18.  
Nat. Hist.  
l. 18. c. 10*

others affirm, that *Bellisarius* in the reign of *Justinian*, did first invent them: Whence *Pancirollus* concludes that it is likely their use was for some space intermitted, and being afterwards renewed again, they were then thought to be first discovered.

*De Rept.  
Tit. 22.*

However 'tis certain, that this invention hath much abridged and advantaged the labours of men, who were before condemned unto this slavery, as now unto the Gallies. And as the force of waters hath been usefull for this, so likewise may it be contrived to divers other purposes. Herein doth the skill of an artificer chiefly consist, in the application of these common motions unto various and beneficiall ends, making them serviceable not onely for the grinding of corn, but for the preparing of iron or other oare, the making of paper, the elevating of water or the like.

*Ad Pistri-  
um.*

To this purpose also are the Mills that are driven by wind, which are so much more convenient then the other, by how much their situations

may be more easie and comon. The motions of these may likewise be accommodated to as various uses as the other, there being scare any labour, to the performance of which, an ingenious artificer cannot apply them. To the sawing of Timber, the plowing of land, or any other the like service, which cannot be dispatched the ordinary way, without much toil and tediousness. And it is a wonderful thing to consider, how much mens labours might be eased and contracted in sundry particulars, if such as were well skilled in the principles and practises of these Mechanicall experiments, would but thorowly apply their studies unto the enlargement of such inventions.

There are some other motions by wind or air, which (though they are not so common as the other, yet may prove of excellent curiosity, and singular use. Such was that musicall instrument invented by *Cornelius Dreble*, which being set in the sun-shine, would of it self render a soft and pleasant

Marcell.  
Franklin.  
Epist ad  
Job. Erne  
stum.



pleasant harmony, but being removed into the shade would presently become silent. The reason of it was this: the warmth of the sun, working upon some moisture within it, and rarifying the inward air unto so great an extension, that it must needs seek for a vent or issue, did thereby give several motions unto the instrument.

Somewhat of this nature are the *Æolipiles*, which are concave Vessels, consisting of some such material as may indure the fire, having a small hole, at which they are filled with water, and out of which (when the Vessels are heated) the air doth issue forth with a strong and lasting violence. These are frequently used for the exciting and contracting of heat in the melting of glasses or metals. They may also be contrived to be serviceable for sundry other pleasant uses, as for the moving of sails in a chimney corner, the motion of which sails may be applied to the turning of a spit, or the like.

But there is a better invention to

L 3

this

Like that  
statue of  
*Memnon*  
in *gypt*,  
which  
makes a  
strange  
noise when  
ever the  
sun begins  
to shine  
upon it.  
*Tacit. An*  
*nal. 2.*  
*Strabo* as-  
firmeth  
he had  
both seen  
and heard  
it.

De Variet.  
Re:um,  
l. 12. c. 58.

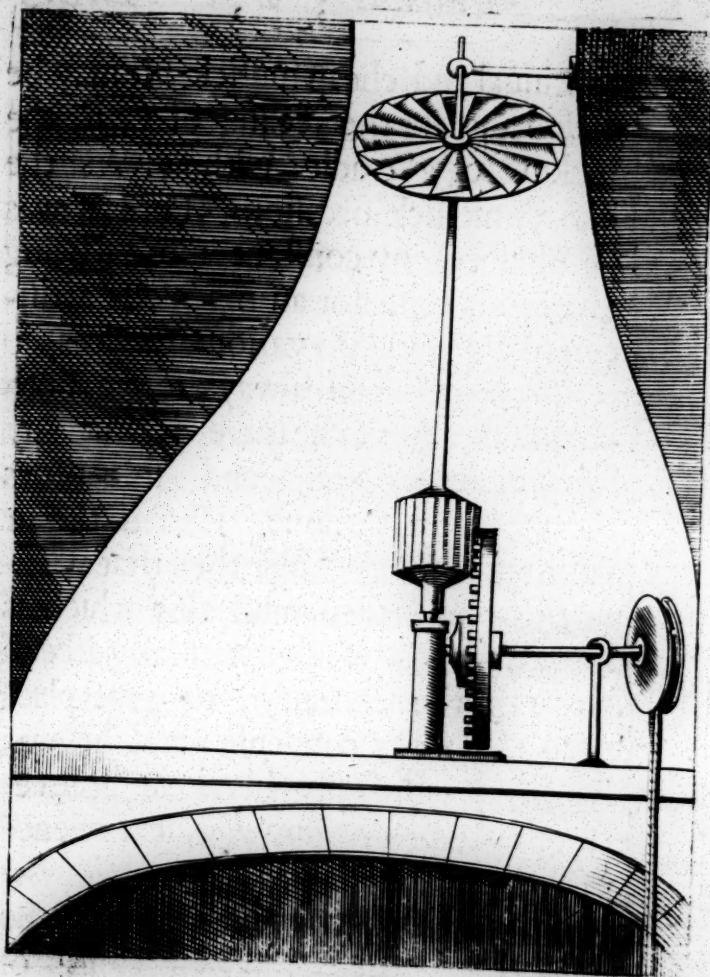
this purpose mentioned in *Cardan*, whereby a spit may be turned (without the help of weights) by the motion of the air that ascends the Chimney; and it may be usefull for the roasting of many or great joints: for as the fire must be increased according to the quantity of meat, so the force of the instrument will be augmented proportionably to the fire. In which contrivance there are these conveniences above the Jacks of ordinary use.

1. It makes little or no noise in the motion.

2. It needs no winding up, but will constantly move of it self, while there is any fire to rarifie the air.

3. It is much cheaper then the other instruments that are commonly used to this purpose. There being required unto it onely a pair of sails, which must be placed in that part of the chimnie where it begins to be straightned, and one wheel to the axis of which the spit line must be fastned, according to this following Diagram.

The



The motion of these sails may likewise be serviceable for sundry other purposes, besides the turning of a spit; for the chiming of bells or other musical devices; and there cannot be any more pleasant contrivance for

continual and cheap musick. It may be usefull also for the reeling of yarn, the rocking of a cradle, with divers the like domestick occasions. For (as was said before) any constant motion being given, it is easie for an ingenious artificer to apply it unto various services.

These sails will always move both day and night, if there is but any fire under them, and sometimes though there be none. For if the air without be much colder then that within the room, then must this which is more warm and rarified, naturally ascend through the chimney, to give place unto the more condensed and heavy, which does usually blow in at every chink or cranny, as experience shews.

Unto this kind of motion may be reduced all those representations of living creatures, whether birds, or beasts, invented by *Ctesibius*, which were for the most part performed by the motion of air, being forced up either by *rarefaction*, with fire, or else by *compression*, through the fall  
of



of some heavier body, as water, which by possessing the place of the air, did thereby drive it to seek for some other vent.

I cannot here omit ( though it be not altogether so pertinent ) to mention that late ingenious invention of the winde-gun, which is charged by the forcible compression of air, being injected through a Syringe; the strife and distention of the imprisoned air serving by the help of little falls or shuts within, to stop and keep close the vents by which it was admitted. The force of it in the discharge is almost equall to our powder-guns. I have found upon frequent trials (saith *Mersennus*) that a leaden bullet shot from one of these Guns against a stone wall, the space of 24 paces from it, will be beaten into a thin plate. It would be a considerable addition to this experiment which the same Authour mentions a little after, whereby he will make the same charge of air to serve for the discharge of several arrows or bullets after one another,

*Phænomena  
pneumatica,  
prop. 32.*

nother, by giving the air onely so much room, as may immediatly serve to impresse a violence in sending away the arrow or bullet, and then screwing it down again to its former confinement, to fit it for another shooting. But against this there may be many considerable doubts, which I cannot stand to discusse.

## CAP. II.

*Of a sailing Chariot, that may without horses be driven on the land by the wind as ships are on the sea.*

THE force of wind in the motion of sails may be applied also to the driving of a Chariot, by which a man may sail on the land as well as by a ship on the water. The labour of horses or other beasts, which are usually applied to this purpose, being artificially suppli-  
ed by the strength of winds.

That such Chariots are commonly used in the Champion plains of *China*, is frequently affirmed by divers credible Authors. *Boterus* mentions that they have been tried also in *Spain*, though

*De incre-  
mento Ur-  
bium, l. 1.  
c. 10.*

though with what success he doth not  
specifie. But above all other experimēts  
to this purpose, that sailing Chariot at  
*Sceveling* in *Holland*, is more eminently  
remarkable. It was made by the dire-  
ction of *Stephinus*, & is celebrated by  
many Authors. \* *Walchius* affirms it

to be of so great a swiftnesse for its  
motion, and yet of so great a capacity  
for its burden. *Ut in medio freto secundis  
ventis commissas naves, velocitate multis  
parasangis post se relinquat, & paucarum  
horarum spatio, viginti aut triginta millia-  
ria Germanica cōtinuo cursu emetiatur, con-  
creditosq; sibi plus minus vectores sex aut  
decē, in petitum locum trāsferat, facillimo  
illius ad clavum qui sedet nutu, quaque  
versum minimo labore velis commissum,  
mirabile hoc continenti currus navigium  
dirigentis.* That it did far exceed the  
speed of any ship, though we should  
suppose it to be carried in the open sea  
with never so prosperous wind: and that  
in some few hours space it would con-  
vey 6 or 10 persons, 20 or 30 German  
miles, and all this with very little la-  
bour of him that sitteth at the Stern,  
who

\* *Fabula-  
rum decas,  
Fab. 9:*

who may easily guide the course of it as he pleaseth.

That eminent inquisitive man *Peireskius*, having travelled to *Sceveling* for the sight and experience of this chariot, would frequently after with much wonder mention the extream swiftness of its motion. *Commemorare solebat stuporē quo correptus fuerat cum vento translatus citatissimo non persentiscere tamen, nempe tā citus erat quā ventus.* Though the wind were in it self more swift and strong, yet to passengers in this Chariot it would not be at all discernable, because they did go with an equall swiftness to the wind it self. Men that ran before it seeming to go backwards, things which seem at a great distance being presently overtaken and left behind. In two houres space it would pass from *Sceveling* to *Putten*, which are distant from one another above 14 *Horaria milliaria* (saith the same Author) that is more then two and forty miles.

*Grotius* is very copious and elegant in the celebrating of this invention, and  
the

*Pet. Gassendus. Vita Peireskii, l. 2.*



the Authour of it in divers Epigrams.

*Ventivola[m] Tiphys deduxit in aquora navim,  
Jupiter in stellas, æthereamque domum.*

*In terre stre solum virtus Stevinia, nam nec  
Tiphys iuvum fuerat, nec Jovis istud opus.*

And in another place,

*Imposuit plastro vestantem carbasa malum*

*An potius navi, subdidit ille rotas?*

*--Scandit aquas navis curvus ruit ære prono,*

*Et merito dicas hic volat, illa natat.*

These relations did at the first seem unto me, (and perhaps they will so to others) somewhat strange and incredible. But upon farther enquiry I have heard them frequently attested from the particular eye-sight and experience of such eminent persons, whose names I dare not cite in a businesse of this nature, which in those parts is so very common, and little observed.

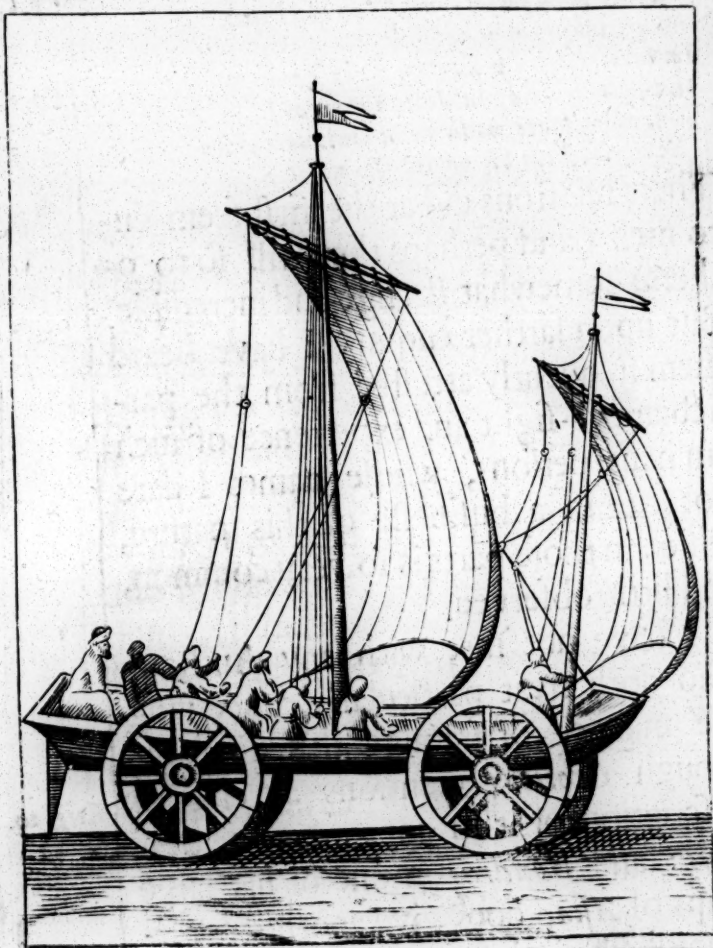
I have not met with any Authour who doth treat particularly concerning the manner of framing this Chariot, though *Grotius* mentions an elegant description of it in copper by one *Geynius*: and *Hondius* in one of his large maps of *Asia*, does give another conjecturall description of the like Chariots used in *China*.

The form of it is related to be very simple and plain, after this manner,

*Grotii Poemata,  
Ep. 19*

*Ep. 5.*

*Epig. 10.  
& 21.*

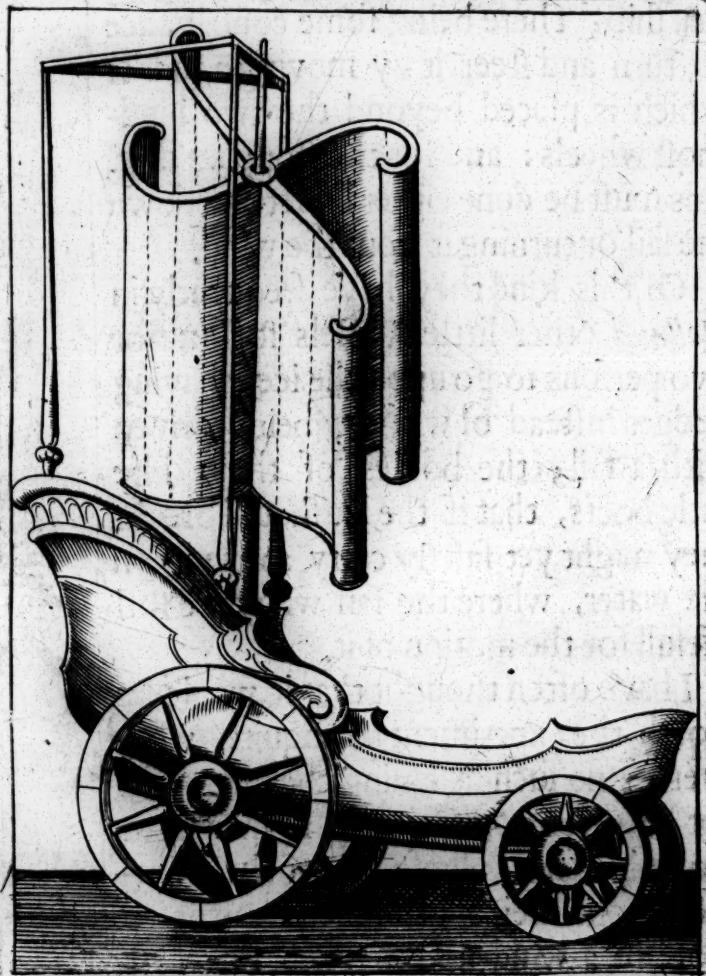


The body of it being somewhat like a boat, moving upon 4 wheels of an equall bigness, with two sails like those in a ship; there being some contrivance to turn and steer it by moving a rudder which is placed beyond the two hindmost wheels: and for the stopping of it, this must be done either by letting down the sail or turning it from the wind.

Of this kind they have frequently in *Holland* other little Vessels for one or two persons to go upon the ice, having sledges instead of wheels, being driven with a sail; the bodies of them like little boats, that if the ice should break, they might yet safely carry a man upon the water, where the sail would be still usefull for the motion of it.

I have often thought that it would be worth the experiment to enquire, whether or no such a sailing chariot might not be more conveniently framed with moveable sails, whose force may be imprest from their motion, equivalent to those in a wind-mill. Their foremost wheels (as in other Chariots) for the greater facility, being somewhat lower then the other, answerable to this figure.

6





In which the sails are so contrived, that the wind from any Coast will have a force upon them to turn them about, and the motion of these sails must needs turn the wheels, and consequently carry on the Chariot it self to any place (though fully against the wind) whither it shall be directed.

The chief doubt will be, whether in such a contrivance every little ruggednesse or unevennesse of the ground, will not cause such a jolting of the Chariot as to hinder the motion of its sails. But this perhaps (if it should prove so) is capable of severall remedies.

I have often wondred, why none of our Gentry who live near great Plaines, and smooth Champions, have attempted any thing to this purpose. The experiments of this kind being very pleasant, and not costly: what could be more delightfull or better husbandry, then to make use of the *mind* (which costs nothing, and eats nothing) in stead of *horses*? This being very easie to be effected by those,

M

the

the convenience of whose habitations doth accommodate them for such experiments.

### C A P. III.

*Concerning the fixed Automata, Clocks, Spheres, representing the heavenly motions : The severall excellencies that are most commendable in such kind of contrivances.*

**T**He second kind of αὐτόματα were described to be such Engines, as did receive a regular and lasting motion from something belonging to their own frame, whether weights, or springs, &c.

They are usually distinguished into αὐτόματα

ἑστάτα, fixed and stationary.

ῥιπιδύοντα, moveable and transient.

1. The fixed are such as move only according to their severall parts, and not according to their whole frame ; In which, though each wheel hath a distinct rotation, yet the whole doth still remain unmoved. The chiefest kind

kind of these are the clocks and watches in ordinary use, the framing of which is so commonly known by every Mechanick, that I shall not trouble the Reader with any explication of it. He that desires fuller satisfaction, may see them particularly described by \* *Cardan*, † *D. Flood*, and others.

The first invention of these (saith *Pancirollus*) was taken from that experiment in the multiplication of wheels mentioned in *Vitruvius*, where he speaks of an instrument whereby a man may know how many miles or paces he doth goe in any space of time, whether or no he doe passe by water in a boat or ship, or by land in a chariot or coach: they have been contrived also into little pocket instruments, by which after a man hath walked a whole day together, he may easily know how many steps he hath taken. I forbear to enter upon a larger explication of these kind of Engines, because they are impertinent unto the chief businesse that

\* *De Vari-  
et. Rec. l. 9.*

*C. 47.*

† *Tract. 2.  
part. 7. l. 1.*

*cap. 4.*

*Reper. Tit.*

*10.*

*Architect.*

*l. 10. c. 14.*

I have proposed for this discourse. The Reader may see them more particularly describ'd in the above cited place of *Vitruvius*, in \* *Cardan*, † *Bessonius*, and others; I have here only mentioned them, as being the first occasion of the chiefest *αὐτόματα* that are now in use.

Of the same kind with our clocks and watches ( though perhaps more elaborate and subtle ) was that sphere invented by *Archimedes*, which did represent the heavenly motions: the diurnall and annuall courses of the sun, the changes and aspects of the Moon, &c. This is frequently celebrated in the writings of the Ancients, particularly in that known *Epigram* of *Claudian*:

*Jupiter in parva cum cerneret aethra vitro,  
Risit, & ad Superos talia dicta dedit;  
Hucine mortalis progressa potentia cura?  
Jam mens in fragili luditur orbe labor.  
Jura poli, rerumque fidem, legesque Deorum,  
Ecce Syracusius transtulit arte senex.  
Inclusus variis famulatur \* spiritus astris,  
Et vivum certis motibus urget opus.*

Per-

\* *Subtil.*

l. 18.

† *Theatrum  
instrumen-  
torum.*

*Wecker de  
secretis. l.*

15. c. 32.

Mention-  
ed by *Ci-  
cero. Tus-  
cul. Quæst.  
l. 1. item  
De Nat.  
Deorū l. 1.*

\* The se-  
cret force  
frō which  
the mo-ior  
was im-  
press'd.



*Percurrit proprium mentitus Signifer annum;  
 Et simulata novo Cynthia mense redit.  
 Jamq; suum volvens audax industria mundū  
 Gaudet, & humanā sidera mente regit.  
 Quid falso insontem tonitru Salmonaea miror?  
 Emula natura parva reperta manus.*

Excellently Translated by  
*T. Randolph.*

*Jove* saw the heavens fram'd in a little glass,  
 And laughing, to the gods these words did passe;  
 Comes then the power of mortall cares so far?  
 In brittle orbs my labours acted are.  
 The statutes of the Poles, the faith of things,  
 The laws of Gods, this *Syracusan* brings  
 Hither by art: Spirits inclos'd attend  
 Their severall spheres, and with set motions bend  
 The living work: each year the feigned Sun,  
 Each month returns the counterfeited Moon.  
 And viewing now her world, bold industry  
 Grows proud, to know the heavens his subjects be.  
 Believe, *Salmoncus* hath false thunders thrown,  
 For a poor hand is natures rivall grown.

But that this Engine should be made  
 of glasse, is scarce credible, *Lactantius*  
 mentioning the relation of it, affirms  
 it to consist of brasse, which is more  
 likely. It may be the outside or case  
 was glasse, and the frame it self of  
 brasse. *Cælius Rhodoginus*, speaking of  
 the wondrous art in the contrivance

*Instis. l. 2.  
 c. 5.*

*Antiq. cœl  
 l. 2. c. 16.*

Guid. u-  
baldus præf.  
ad Mechan.

Collect.  
Mathem.  
Præm. ad  
l. 8.

De Vanit.  
Scient. cap.  
22. Schol.  
Math. l. 1.  
So Cardan  
100 l. 17.  
Monanib.  
in Mecha.  
Arist. Com.  
c. 1.  
Dr. Hack-  
wel, Apol.  
l. 2. c. 10.  
sect. 1.  
\* De vitâ  
Archime-  
dis.

of this Sphere, breaks out into this  
quære. *Nonne igitur miraculorum omni-  
um maximum miraculum est homo ?* He  
might have said *Mathematicus* : And  
another to this purpose, *Sic manus  
ejus naturam, ut natura ipsa manum imi-  
tata putetur.* Pappus tells us, that *Archimedes* writ a Book *de Sphæropæia* con-  
cerning the manner of framing such  
Engines, and after him *Posidonius* com-  
posed another discourse on the same  
subject, though now either the igno-  
rance or the envy of time hath de-  
prived us of both those works. And  
yet the art it self is not quite perished,  
for we read of divers the like contrivan-  
ces in these latter times. *Agrippa* af-  
firms that he himself had seen such a  
sphere, and *Ramus* tels us how he beheld  
two of them in *Paris*, the one brought  
thither amongst other spoiles from  
*Sicily*, and the other out of *Germany*.  
And it is commonly reported, that  
there is yet such a sphere at *Stras-  
burg* in *Germany*. \* *Rivaltus* relates  
how *Marinus Burgesius* a *Norman* made  
two of them in *France* for the King.

And

And perhaps these latter (saith he) were more exact then the former, because the heavenly revolutions are now much better understood then before. And besides it is questionable, whether the use of steel springs was known in those ancient times; the application of which unto these kind of spheres; must needs be much more convenient then weights.

'Tis related also of the Consul *Boethius*, that amongst other Mathematical contrivances, (for which he was famous) he made a sphere to represent the Suns motion, which was so much admired, and talked of in those times, that *Gundibaldus* King of *Burgundie*, did purposely send over Embassadors to *Theodericus* the Emperour, with intreaties that he would be a means to procure one of these spheres from *Boethius*; the Emperor thinking hereby to make his kingdom more famous and terrible unto forain Nations, doth write an Epistle to *Boethius*, perswading him to send this instrument. *Quoties non sunt credituri*

*Cassiodor.  
Chron. Pet.  
Bertius  
praef. ad  
Consulat.  
Philos.*

*quod viderint ? Quoties hanc veritatem lusoria somnia putabunt ? Et quando fuerint à stupore conversi, non audebunt se aequales nobis dicere, apud quos sciunt sapientes talia cogitasse.* So much were all these kind of inventions admired in those ruder and darker times: whereas the instruments that are now in use amongst us ( though not so much extolled ) yet doe altogether equall ( if not exceed ) the other both in usefulness and subtilty. The chiefest of these former Engines receiving their motion from weights, and not from springs, which (as I said before) are of later and more excellent invention.

*Polyd. Virgil. de invent. rerum  
l. 2. c. 5.  
Cardan  
Subl. l. 17.*

The particular circumstances for which the *Automata* of this kind, are most eminent, may be reduced to these four.

1. The lastingness of their motion, without needing any new supply; for which purpose there have been some watches contrived to continue without winding up for a week together, or longer.

2. The



2. The easinesse and simplicity of their composition ; Art it self being but the facilitating and contracting of ordinary operations, therefore the more easie and compendious such inventions are, the more artificial should they be esteemed. And the addition of any such unnecessary parts, as may be supplied some other way, is a sure sign of unskillfulnesse and ignorance. Those antiquated Engines that did consist of such a needless multitude of wheels, and springs, and screws, (like the old *hypothesis* of the heavens) may be compared to the notions of a confused knowledge, which are always full of perplexity and complications, and seldome in order; whereas the inventions of art are more regular, simple and perspicuous, like the apprehensions of a distinct and thoroughly informed judgement. In this respect the manner of framing the ordinary *Automata*, hath been much bettered in these latter times above the former, and shall hereafter perhaps be yet more advantaged.

These

These kind of experiments (like all other humane arts) receiving additions from every days experiment.

To this purpose there is an invention consisting onely of one hollow orb or wheel, whereby the hours may be as truly distinguished, as by any ordinary clock or watch. This wheel should be divided into several cavities, through each of which successively either sand or water must be contrived to passe; the heaviness of these bodies (being always in the ascending side of the wheel) must be counterpoised by a plummet that may be fastned about the pulley on the axis: this plummet will leisurely descend, according as the sand by running out of one cavity into the next, doth make the several parts of the wheel lighter or heavier, and so consequently there will be produced an equall and lasting motion, which may be easily applied to the distinction of hours.

3. The multitude and variety of those services for which they may be

be usefull. Unto this kind may we refer those watches, by which a man may tell not only the hour of the day, but the minute of the hour, the day of the moneth, the age and aspects of the Moon, &c. Of this nature likewise was that larum mentioned by *Walchius*, which though it were but two or three inches big, yet would both wake a man, and of it self light a candle for him at any set houre of the night. And those weights or springs which are of so great force as to turn a mill, (as some have been contrived) may be easily applied to more various and difficult labours.

*Fab. 9.*

*Ramel. fig. 130.*

4. The littleness of their frame. *Nunquam ars magis quam in minimis nota est* (saith *Aquinas*.) The smalness of the Engine doth much commend the skill of the Artificer; to this purpose there have been watches contrived in the form and quantity of a Jewell for the ear, where the striking of the minutes may constantly whisper unto us, how our lives do slide away

Jacks no bigger then a Walnut to turn any joint of meat.

De subtil.  
l. 2. item  
l. 17.

away by a swift succession. Cardan tells us of a Smith who made a watch in the Jewel of a ring, to be worn on the finger, which did shew the houres, (*non solum sagitta, sed ictu*) not only by the hand, but by the finger too (as I may say) by pricking it every hour.

#### C A P. IV.

*Of the moveable and Gradient Automata, representing the motions of living creatures, various sounds, of birds, or beasts, and some of them articulate.*

**T**HUS much of those Automata, which were said to be fixed and stationary.

The other kind to be inquired after, are those that are moveable and transient, which are described to be such engines as move not only according to their severall parts, but also according to their whole frames. These are again distinguishable into two sorts:

1. Gra-



1. *Gradient.*2. *Volant.*

1. The *Gradient* or *ambulatory*, are such as require some *basis* or bottom to uphold them in their motions. Such were those strange inventions (commonly attributed to *Dadalus*) or self-moving statues, which (unless they were violently detained) would of themselves run away. \* *Aristotle* affirms that *Dadalus* did this by putting quick-silver into them. But this would have been too grosse a way for so excellent an artificer, it is more likely that he did it with wheels and weights. Of this kind likewise were *Vulcans Tripodes*, celebrated by *Homer*, that were made to move up and down the house, and fight with one another. He might as well have contrived them into Journey-men statues, each of which with a hammer in his hand should have worked at the forge.

But amongst these fighting images, that in *Cardan* may deserve a mention, which holding in its hand a golden apple, beautified with many costly Jewels;

Plato in  
*Menone.*  
*Arist. Po-*  
*lit. l. 1. c. 3.*

\* *De Ani-*  
*ma. l. 1. c. 3.*

*Iliad. 18.*

There  
have been  
also chari-  
ors driven  
by the  
force of a  
spring  
contrived  
within  
them.  
*De Vaict.*  
*rerum*  
*l. 1. c. 58.*

Jewels; if any man offered to take it, the statue presently shot him to death. The touching of this apple serving to discharge several short bowes, or other the like instruments that were secretly couched within the body of the image. By such a treachery was King *Chennetus* murdered (as *Boethius* relates.

It is so common an experiment in these times to represent the persons and actions of any story by such self-moving images, that I shall not need to explain the manner how the wheels and springs are contrived within them.

*Fab. 9.*

There have been other inventions to move on the water.

*Naviginm  
sponte mo-  
bile, ac  
sui remigii  
autorem,  
faciam nut-  
to negotio,  
saith Sca-  
liger, Ex-  
erc. 3. 26.*

Amongst these gradient *Automata*, that iron spider mentioned in *Walchius*, is more especially remarkable, which being but of an ordinary bignesse, besides the outward similitude, (which was very exact) had the same kind of motions with a living spider, and did creep up and down as if it had been alive. It must needs argue a wonderful art, and accuratenesse, to contrive all the instruments requisite for such

a motion in so small a frame.

There have been also other motions contrived from Magneticall qualities, which will shew the more wonderfull, because there is no apparent reason of their motion, there being not the least contiguity or dependence upon any other body that may occasion it; but it is all one as if they should move up and down in the open air. Get a glasse sphere, fill it with such liquors as may be clear of the same colour, immixable, such as are oyl of tartar, and spirit of wine: In which, it is easie so to poise a little globe or other statue, that it shall swim in the center. Under this glasse sphere, there should be a loadstone concealed, by the motion of which, the statue (having a needle touched within it) will move up and down, and may be contrived to shew the hour or sign. See severall inventions of this kind in *Kircher de arte Magnetica*, l. 2.

There have been some artificiall images, which besides their severall postures in walking up and downe,  
have

have been made also to give severall sounds, whether of birds, as Larks, Cuckoos, &c. or beasts, as Hares, Foxes. The voices of which creatures shall be rendred as clearly and distinctly, by these artificiall images, as they are by those naturall living bodies, which they represent.

There have been some inventions also which have been able for the utterance of articulate sounds, as the speaking of certain words. Such are some of the Ægyptian idols related to be. Such was the brazen head made by Friar *Bacon*, and that statue in the framing of which *Albertus Magnus* bestowed thirty years, broken by *Aquinas*, who came to see it, purposely that he might boast, how in one minute he had ruined the labour of so many years.

Now the ground and reason how these sounds were contrived, may be worth our inquiry.

First then, for those of birds or beasts, they were made from such pipes or cals, as may expresse the severall

*Cæli. Rhod.  
lett. Ant.  
l. 2. c. 17.  
Maiolus  
Collog.*



verall tones of those creatures which are represented: these calls are so commonly known and used, that they need not any further explication.

But now about articulate sounds there is much greater difficulty. *Walchius* thinks it possible entirely to preserve the voice, or any words spoken, in a hollow trunk, or pipe, and that this pipe being rightly opened, the words will come out of it in the same order wherein they were spoken. Somewhat like that cold Countrey, where the peoples discourse doth freeze in the air all winter, and may be heard in the next Summer, or at a great thaw. But this conjecture will need no refutation.

The more substantiall way for such a discovery, is by marking how nature her self doth imploy the severall instruments of speech, the tongue, lips, throat, teeth, &c. To this purpose the Hebrews have assigned each letter unto its proper instrument. And besides, we should observe what inarticulate sounds doe resemble any of  
N the

*Tab. 9.*

Bacon  
Nat. Hist.  
Expe. 1, 9,  
200.

the particular letters. Thus we may note the trembling of water to be like the letter *L*, the quenching of hot things to the letters *Z*, the sound of strings, unto the letter *Ng*, the jirking of a switch the letter *Q*, &c. By an exact observation of these particulars, it is (perhaps) possible to make a statue speak some words.

#### C A P. V.

*Concerning the possibility of framing an Ark for submarine Navigations. The difficulties and conveniences of such a contrivance.*

Traët. de  
Magnētis  
propriētati-  
bus,

**I**T will not be altogether impertinent unto the discourse of these gradient *Automata*, to mention what *Mersennus* doth so largely and pleasantly descant upon, concerning the making of a ship, wherein men may safely swim under water.

That such a contrivance is feasible and may be effected, is beyond all question, because it hath been already

dy experimented here in *England* by *Cornelius Dreble*, but how to improve it unto publike use and advantage, so as to be serviceable for remote voyages, the carrying of any considerable number of men, with provisions and commodities, would be of such excellent use as may deserve some further inquiry.

Concerning which there are two things chiefly considerable:

The { many difficulties with their  
remedies.  
great conveniences.

i. The difficulties are generally reducible to these three heads:

1. The letting out, or receiving in any thing, as there shall be occasion without the admission of water. If it have not such a convenience, these kind of voyages must needs be very dangerous and uncomfortable, both by reason of many noisome offensive things, which should be thrust out, and many other needful things which should be received in. Now herein will consist the difficulty, how to con-

trive the opening of this vessel so, that any thing may be put in or out, and yet the water not rush into it with much violence, as it doth usually in the leak of a ship.

In which case this may be a proper remedy ; let there be certain leather bags made of several bignesses, which for the *matter* of them should be both *tractable* for the use and managing of them, and *strong* to keep out the water, for the *figure* of them being long and open at both ends. Answerable to these, let there be divers windows, or open places in the frame of the ship, round the sides of which one end of these bags may be fixed, the other end coming within the ship being to open and shut as a purse. Now if we suppose this bag thus fastned, to be tyed close about towards the window, then any thing that is to be sent out, may be safely put into that end within the ship, which being again close shut, and the other end loosened the thing may be safely sent out without the admission of any water.

So



So again, when any thing is to be taken in, it must be first received into that part of the bag towards the window, which being (after the thing is within it) close tyed about, the other end may then be safely opened. It is easie to conceive, how<sup>by</sup> this means any thing or person may be sent out, or received in, as there shall be occasion, how the water, which will perhaps by degrees leak into several parts, may be emptied out again, with divers the like advantages. Though if there should be any leak at the bottom of this Vessel, yet very little water would get in, because no air could get out.

2. The second difficulty in such an Ark will be the *motion* or *fixing* of it according to occasion; The *directing* of it to several places, as the voyage shall be designed, without which, it would be very uselesse, if it were to remain only in one place, or were to remove only blindfold, without any certain direction; And the contrivance of this may seem very diffi-

cult, because these submarine Navigators will want the usuall advantages of winds and tides for motion, and the sight of the heavens for direction.

But these difficulties may be thus remedied ; As for the *progressive* motion of it, this may be effected by the help of severall Oars, which in the outward ends of them, shall be like the fins of a fish to contract and dilate. The passage where they are admitted into the ship being tyed about with such leather bags ( as were mentioned before ) to keep out the water. It will not be convenient perhaps that the motion in these voyages should be very swift, because of those observations and discoveries to be made at the bottome of the sea, which in a little space may abundantly recompence the slownesse of its progresse.

If this Ark be so ballast as to be of equall weight with the like magnitude of water. it will then be easily moveable in any part of it.

As for the *ascent* of it, this may be easily contrived, if there be some great weight

weight at the bottome of the ship (being part of its ballast) which by some cord within may be loosened from it; As this weight is let lower, so will the ship ascend from it (if need be) to the very surface of the water; and again, as it is pulled close to the ship, so will it *descend*.

For *direction* of this Ark, the Mariners needle may be useful in respect of the *latitude* of places, and the course of this ship being more regular then others, by reason it is not subject to Tempests or unequall winds, may more certainly guide them in judging of the *longitude* of places.

3. But the greatest difficulty of all will be this, how the air may be supplied for respiration: How constant fires may be kept in it for light and the dressing of food, how those vicissitudes of rarefaction and condensation may be maintained.

It is observed, that a barrel or cap, whose cavity will contain eight cubical feet of air, will not serve a Urinator or Diver for respiration, a-

bove one quarter of an hour ; the breath which is often sucked in and out, being so corrupted by the mixture of vapours, that nature rejects it as unserviceable. Now in an hour a man will need at least 360 respirations, betwixt every one of which there shall be 10 second minutes, and consequently a great change and supply of air will be necessary for many persons, and any long space.

And so likewise for the keeping of fire ; a close Vessel containing ten cubical feet of air, will not suffer a wax candle of an ounce to burn in it above an hour before it be suffocated, though this proportion (saith *Mersennus*) doth not equally increase for severall lights, because four flames of an equall magnitude will be kept alive the space of 16 second minutes, though one of these flames alone in the same Vessel will not last above 25, or at most 30 seconds, which may be easily tried in large glasse bottles, having wax candles lighted in them, and with their mouths inverted in water.

For



For the resolution of this difficulty, though I will not say that a man may by custome ( which in other things doth produce such strange incredible effects ) be inabled to live in the open water as the fishes do, the inspiration and expiration of water serving in stead of air, this being usual with many fishes that have lungs; yet it is certain that long use and custome may strengthen men against many such inconveniences of this kind, which to unexperienced persons may prove very hazardous: and so it will not perhaps be unto these so necessary, to have the air for breathing so pure and defecated as is required for others.

But further there are in this case these three things considerable.

1. That the Vessel it self should be of a large capacity, that as the air in it is corrupted in one part, so it may be purified and renewed in the other: or if the meer refrigeration of the air would fit it for breathing, this might be somewhat helped with bellows.

bellows, which would cool it by motion.

2. It is not altogether improbable, that the lamps or fires in the middle of it, like the reflected beams in the first Region, rarefying the air, and the circumambient coldnesse towards the sides of the Vessel, like the second Region, cooling and condensing of it, would make such a vicissitude and change of air, as might fit it for all its proper uses.

3. Or if neither of these conjectures will help, yet *Mersennus* tells us in another place, that there is in *France* one *Barrieus* a Diver, who hath lately found out another art, whereby a man might easily continue under water for six houres together, and where-as ten cubicall feet of air will not serve another Diver to breath in for half an hour, he by the help of a cavity, not above one or two foot at most, will have breath enough for six houres, and a lanthorn scarce above the usuall size to keep a candle burning as long as a man please, which  
( if

*Harmon.*  
*l. 4 prop. 6.*  
*Moniz.*

( if it be true, and were commonly known ) might be a sufficient help against this greatest difficulty.

As for the many advantages and conveniences of such a contrivance, it is not easie to recite them.

1. 'Tis *private* ; a man may thus go to any coast of the world invisibly, without being discovered or prevented in his journey.

2. 'Tis *safe*; from the uncertainty of *Tides*, and the violence of *Tempests*, which do never move the sea above five or six paces deep. From *Pirates* and *Robbers* which do so infest other voyages ; From ice and great frosts, which doe so much endanger the passages towards the Poles.

3. It may be of very great advantage against a Navy of enemies, who by this means may be undermined in the water and blown up.

4. It may be of speciall use for the relief of any place that is besieged by water, to convey unto them invisible supplies : and so likewise for the surprisal of any place that is accessible by water.

5. It

5. It may be of unspeakable benefit for submarine experiments and discoveries : as

The several proportions of swiftnesse betwixt the ascent of a bladder, cork, or any other light substance in comparison to the descent of stones or lead. The deep caverns and subterraneous passages where the seawater in the course of its circulation, doth vent it self into other places, and the like. The nature and kinds of fishes, the several arts of catching them, by alluring them with lights, by placing divers nets about the sides of this Vessel, shooting the greater sort of them with guns, which may be put out of the ship by the help of such bags as were mentioned before, with divers the like artifices and treacheries, which may be more successively practised by such who live so familiarly together. These fish may serve not only for food, but for fewell likewise, in respect of that oyl which may be extracted from them; the way of dressing meat by lamps, being



ing in many respects the most convenient for such a voyage.

The many fresh springs that may probably be met with in the bottome of the sea, will serve for the supply of drink and other occasions.

But above all, the discovery of submarine treasures is more especially considerable, not only in regard of what hath been drowned by racks, but the severall precious things that grow there, as Pearl, Corall, Mines, with innumerable other things of great value, which may be much more easily found out, and fetcht up by the help of this, then by any other usuall way of the Urinators.

To which purpose, this great Vessel may have some lesser cabins tyed about it, at various distances, wherein severall persons, as Scouts, may be lodged for the taking of observations, according as the Admirall shall direct them. Some of them being frequently sent up to the surface of the water, as there shall be occasion.

All

All kind of arts and manufactures may be exercis'd in this Vessel. The observations made by it, may be both written, and (if need were) printed here likewise. Several Colonies may thus inhabit, having their children born and bred up without the knowledge of land, who could not chuse but be amazed with strange conceits upon the discovery of this upper world.

I am not able to judge what other advantages there may be suggested, or whether experiment would fully answer to these notionall conjectures. But however, because the invention did unto me seem ingenious and new, being not impertinent to the present enquiry, therefore I thought it might be worth the mentioning.

C A P.

## CAP. VI.

*Of the volant Automata, Archytas his Dove, and Regiomontanus his Eagle. The possibility and great usefulness of such inventions.*

**T**He volant or flying Automata are such Mechanicall contrivances, as have a self-motion, whereby they are carried aloft in the open air, like the flight of Birds. Such was that wooden Dove made by *Archytas*, a Citizen of *Tarentum*, and one of *Plato's* acquaintance. And that wooden Eagle framed by *Regiomontanus* at *Noremberg*, which by way of triumph, did fly out of the City to meet *Charles* the fifth. This later Author is also reported to have made an iron fly, *Quæ ex artificis manu egressa, convivas circumvolitarvit, tandemque veluti defessa in Domini manus reversa est*, which when he invited any of his friends, would fly to each of them round the table, and at length (as being weary) return unto its Master.

*Cardan*

*Diog. Laert.*  
l. 8.

*Per. Crinitus de honest. discip.*  
l. 17. c. 12.

*Ramus Schol. Mathematicæ* l. 2.

*Dubartas*  
6 days 1 W.  
J. Dec Pre-  
face to Eu-  
clid.

*De Variet.  
rerum lib.  
12. c. 58.*

*Cardan* seems to doubt the possibility of any such contrivance; his reason is, because the instruments of it must be firm and strong, and consequently they will be too heavy to be carried by their own force; but yet (saith he) if it be a little helped in the first rising, and if there be any wind to assist it in the flight, then there is nothing to hinder, but that such motions may be possible. So that he doth in effect grant as much as may be sufficient for the truth and credit of those ancient relations; and to distrust them without a stronger argument, must needs argue a blind and perverse incredulity. As for his objection concerning the heaviness of the materials in such an invention, it may be answered that it is easie to contrive such springs and other instruments, whose strength shall much exceed their heaviness. Nor can he shew any cause why these Mechanicall motions may not be as strong, (though not so lasting) as the natural strength of living creatures.

*Scaliger*



Scaliger conceives the framing of such volant Automata, to be very easie. *Volantis columba machinulam, cujus auctorem Archytam tradunt, vel facillime profiteri audeo.* Those ancient motions were thought to be contrived by the force of some included air: So Gellius, *Ita erat scilicet libramentis suspensum, & aurâ spiritus inclusâ atque occultâ constitum, &c.* As if there had been some lamp, or other fire within it, which might produce such a forcible rarefaction, as should give a motion to the whole frame.

But this may be better performed by the strength of some such spring as is commonly used in watches; this spring may bee applyed unto one wheel, which shall give an equall motion to both the wings; these wings having unto each of them another smaller spring by which they may be contracted and lifted up: So that being forcibly depressed by the strength of the great and stronger spring, and lifted up again by the other two. According to this suppo-

O

sition,

Subtil.  
Exercit.  
326.

Not. At.  
tic. l. 10.  
cap. 12.  
where he  
thinks it  
so strange  
an inven-  
tion that  
he styles  
Res abhor-  
rens à fide  
Athanas.  
Kircher de  
Magnete  
l. 2. par. 4.  
Proem:  
doth pro-  
mise a  
large dis-  
course co-  
cerning  
these kind  
of inventi-  
ons in a-  
nother.  
Treatise  
which he  
styles Oc-  
dipus æ-  
gyptiacus

sition, it is easie to conceive how the motion of flight may be performed and continued.

The wings may be made either of *severall substances joyned*, like the feathers in ordinary fowl, as *Dædalus* is feigned to contrive them, according to that in the Poet,

Ovid. *Metam.*  
l. 8.

-- *Ignotas animum dimittit in artes,  
Naturamque novat, nam ponit in ordine pennas*

*A minimo cæptas longam brevior sequente,*

*Ut clivo crevisse putes, &c.*

Or else of *one continue substance*, like those of Bars. In framing of both which, the best guidance is to follow (as neer as may be) the direction of nature; this being but an imitation of a naturall work. Now in both these, the strength of each part is proportioned to the force of its imployment. But nothing in this kind can be perfectly determined without a particular triall.

Though the composing of such motions may be a sufficient reward to any ones industry in the searching  
at-

after them, as being in themselves of excellent curiosity; yet there are some other inventions depend upon them of more generall benefit and greater importance. For if there be any such artificial contrivances that can flye in the air, ( as is evident from the former relations, together with the grounds here specified, and I doubt not, may be easily effected by a diligent and ingenious artificer ) then it will clearly follow, that it is possible also for a man to fly himself: It being easie from the same grounds to frame an instrument, wherein any one may sit, and give such a motion unto it, as shall convey him aloft through the air. Then which there is not any imaginable invention that could prove of greater benefit to the world, or glory to the Author. And therefore it may justly deserve their enquiry, who have both leisure and means for such experiments.

But in these practical studies, unlesse a man be able to goe to the tryall of things, he will perform but  
O z little.

Horace.

little. In such matters,

*-Studium sine divite venâ,*

(as the Poet saith) a generall speculation, without particular experiment, may conjecture at many things, but can certainly effect nothing. And therefore I shall onely propose unto the world, the Theory and generall grounds that may conduce to the easie and more perfect discovery of the subject in question, for the encouragement of those that have both minds and means for such experiments. This same Scholars fate,

*Res angusta domi, and**--curta supellex.*

is that which hinders the promoting of learning in sundry particulars, and robs the world of many excellent inventions. We read of *Aristotle*, that he was allowed by his pupill *Alexander* 800 talents a year, for the payment of Fishers, Fowlers, and Hunters, who were to bring him in severall creatures, that so by his particular experience of their parts and dispositions, he might be more fitly prepared



pared to write of their natures. The reason why the world hath not many *Aristotles* is, because it hath so few *Alexanders*.

Amongst other impediments of any strange invention or attempts, it is none of the meanest discouragements, that they are so generally derided by common opinion, being esteemed only as the dreams of a melancholy and distempered fancy. *Eusebius* speaking with what necessity every thing is confined by the laws of nature, and the decrees of providence, so that nothing can go out of that way, unto which naturally it is designed; as a fish cannot reside on the land, nor a man in the water, or aloft in the air, infers, that therefore none will venture upon any such vain attempt, as passing in the air, ἡ μελαγχολίας νοσήματα ἀν' ἀπείσοι, unlesse his brain be a little crazed with the humour of melancholy; whereupon he advises that we should not in any particular endeavour to transgresse the bounds of nature, ἡ δὲ ἀπτερον ἔχοντα τὸ σῶμα, τὰ τῶ

*Contra Hierosol. confut. l. i.*

ἄνθρωπον ἐπιτυθεύειν, and since we are naturally destitute of wings, not to imitate the flight of Birds. That saying of the Poet,

Virgil.  
Æneid.  
l. 6.

*Demens qui nimbos & non imitabile  
fulmen, &c.*

hath been an old censure applyed unto such as ventured upon any strange or incredible attempt.

Hence may we conceive the reason, why there is so little intimation in the writings of antiquity, concerning the possibility of any such invention. The Ancients durst not so much as mention the art of flying, but in a fable.

*Dædalus, ut fama est, fugiens Minoia  
regna,*

*Præpetibus pennis ausus se credere cælo,  
Insuetum per iter gelidas enavit ad ar-  
ctos, &c.*

It was the custome of those former ages, in their overmuch gratitude, to advance the first Authors of any usefull discovery, amongst the number of their gods. And *Dædalus* being so famous amongst them for  
sundry

undry Mechanicall inventions (especially the sails of ships) though they did not for these place him in the heavens, yet they have promoted him as near as they could, feigning him to fly aloft in the air, when as he did but fly in a swift ship, as *Diodorus* relates the Historicall truth, on which that fiction is grounded.

So Euse-  
bius too.

## CAP. VII.

*Concerning the Art of flying. The severall wayes whereby this hath been or may be attempted.*

I Have formerly in two other \* Discourses mentioned the possibility of this art of flying, and intimated a further inquiry unto it, which is a kind of engagement to some fuller disquisitions and conjectures to that purpose.

There are four severall wayes whereby this flying in the air, hath been or may be attempted. Two of them by the strength of other things, and

World in  
the Moon,  
c. 14.  
Mercury,  
or the se-  
cret and  
swift Mes-  
senger c 4.

two of them by our own strength.

1. By spirits or Angels.

2. By the help of fowls.

3. By wings fastned immediately to the body.

4. By a flying chariot.

i. For the first we read of divers that have passed swiftly in the air, by the help of spirits and Angels, whether good Angels, a \* *Elias* was carried into heaven in a fiery chariot: as † *Philip* was conveyed to *Azotus*, and *Habbacuck* from Jewry to Babylon, and back again immediately: Or by evil Angels, as our Saviour was carried by the Devill to the top of a high mountain, and to the pinnacle of the Temple. Thus witches are commonly related to passe unto their usual meetings in some remote place; and as they doe sell windes unto Mariners, so likewise are they sometimes hired to carry men speedily through the open air. *Acosta* affirms that such kind of passages are usuall amongst divers Sorcerers with the Indians at this day.

So

*Zanch. de  
oper pars 1.  
l. 4.*

\* 2 Kings  
2. 11.

† Acts 8.  
39.  
Dan. A-  
poc. 39.

Luke 4.

*Erastus de  
Lamiis.*

*Hist. Ind.  
l. 5 c. 26.*



So *Kepler* in his *Astronomically* dream doth fancy a *Witch* to be conveyed unto the *Moon* by her *Familiar*.

*Simon Magus* was so eminent for miraculous forceries, that all the people in *Samaria* from the least to the greatest did esteem him *as the great power of God*. And so famous was he at *Rome*, that the Emperour erected a statue to him with this Inscription, *Simoni Deo Sancto*. 'Tis storied of this Magician, that having challenged *Saint Peter* to do miracles with him, he attempted to flie from the Capitol to the *Aventine hill*. But when he was in the midst of the way, *Saint Peters* prayers did overcome his forceries, and violently bring him to the ground, in which fall having broke his thigh, within a while after he died.

But none of all these relations may conduce to the discovery of this experiment, as it is here enquired after, upon *natural* and *artificial* grounds.

2. There are others who have con-

*Acts* 8. 10

*Heg. lib* 1. 3

c. 2.

*Pol. Virgil.*  
*de Inven.*

*Rerum.* 1. 8.

c. 3.

*Pet. Crinitus* de *Honestâ Disciplinâ*. l. 8.

c. 1. mistrusts this relation as fabulous.

*Non enim Lucas hoc omisit.*

conjectured a possibility of being conveyed through the air by the help of Fowls; to which purpose that fiction of the *Ganza's*, is the most pleasant and probable. They are supposed to be great fowl of a strong lasting flight, and easily tamable. Divers of which may be so brought up as to joyn together in carrying the weight of a man, so as each of them shall partake his proportionable share of the burden; and the person that is carried may by certain reins direct and steer them in their courses. However this may seem a strange proposal, yet it is not certainly more improbable, then many other arts, wherein the industry of ingenious men hath instructed these brute creatures. And I am very confident, that one whose genius doth enable him for such kind of experiments, upon leisure, and the advantage of such helps as are requisite for various and frequent trials, might effect some strange thing by this kind of enquiry.

'Tis reported as a custome amongst  
the

the *Leucadians*, that they were wont upon a superstition to precipitate a man from some high cliffe into the sea, tying about him with strings at some distance, many great fowls, and fixing unto his body divers feathers spread, to break the fall; which (saith the learned *Bacon*, if it were diligently and exactly contrived) would be able to hold up, and carry any proportionable weight; and therefore he advises others to think further upon this experiment, as giving some light to the invention of the art of flying.

*Nat. Hist.  
experim.  
886.*

3. 'Tis the more obvious and common opinion that this may be effected by wings fastned immediately to the body, this coming nearest to the imitation of nature, which should be observed in such attempts as these. This is that way which *Fredericus Hermannus* in his little discourse *de Arte volandi*, doth onely mention and insist upon. And if we may trust credible story, it hath been frequently attempted not without some successe.

*So the ancient  
British  
Bladdes.*

'Tis

Ernestus  
Burgravius  
in Panoplia  
Physico-  
Vulcania.  
Sturmius  
in Lat:  
linguæ re-  
solut.

Melancholy Part 2.  
Sect. 1.  
Mem. 3.

'Tis related of a certain English Monk called *Elmerus*, about the Confessors time, that he did by such wings fly from a Tower above a furlong; and so another from Saint Marks steeple in *Venice*; another at *Norinberge*; and *Busbequius* speaks of a Turk in *Constantinople*, who attempted something this way. Mr. *Burton* mentioning this quotation, doth believe that some new-fangled wit ('tis his cynicall phrase) will some time or other find out this art. Though the truth is, most of these Artists did unfortunately miscarry by falling down and breaking their arms or legs, yet that may be imputed to their want of experience, and too much fear, which must needs possesse men in such dangerous and strange attempts. Those things that seem very difficult and fearfull at the first, may grow very facil after frequent triall and exercise. And therefore he that would effect any thing in this kind, must be brought up to the constant practise of it from his youth. Try-  
ing



ing first onely to use his wings in running on the ground, as an Estrich or tame Geese will doe, touching the earth with his toes; and so by degrees learn to rise higher, till he shall attain unto skill and confidence. I have heard it from credible testimony, that one of our own Nation hath proceeded so far in this experiment, that he was able by the help of wings in such a running pace to step constantly ten yards at a time.

It is not more incredible that frequent practise and custome should enable a man for this, then for many other things which we see confirmed by experience. What strange agility and activenesse doe our common tumblers and dancers on the rope attain to by continuall exercise? 'Tis related of certain Indians, that they are able when a horse is running in his full career, to stand upright on his back, to turn themselves round, to leap down, gathering up any thing from the ground, and immediately to leap up again, to shoot exactly at any mark. the horse not inter-

mitting

*Maffæus  
Hist. Ind.  
l. 1.*

mitting his course. And so upon two horses together, the man setting one of his feet upon each of them. These things may seem impossible to others, and it would be very dangerous for any one to attempt them, who hath not first gradually attained to these arts, by long practise and triall; and why may not such practise enable him as well for this other experiment, as for these things?

There are others who have invented wayes to walk upon the water, as regularly and firmly as upon the land. There are some so accustomed to this element, that it hath been almost as naturall to them, as to the fish; men that could remain for above an hour together under water. *Pontanus* mentions one who could swim above a hundred miles together, from one shore to another, with great speed, and at all times of the year. And it is storied of a certain young man, a *Sicilian* by birth, and a *Diver* by profession, who had so continually used himself to the water, that he could  
not

Treatise  
of custom.

not enjoy his health out of it. If at any time he staid with his friends on the land, he should be so tormented with a pain in his stomach, that he was forced for his health to return back again to sea; wherein he kept his usuall residence, and when he saw any ships, his custome was to swim to them for relief, which kind of life he continued till he was an old man, and dyed.

I mention these things to shew the great power of practise and custome, which might more probably succeed in this experiment of flying (if it were but regularly attempted) then in such strange effects as these.

It is a usuall practise in these times, for our *Funambulones*, or Dancers on the Rope, to attempt somewhat like to flying, when they will with their heads forwards slide downe a long cord extended; being fastned at one end on the top of some high Tower, and the other at some distance on the ground, with wings fixed to their shoulders, by the shaking of which they

\*De guber.  
Dei. l. 6.

Annot in  
Salvi.

they will break the force of their descent. It would seem that some attempts of this kind were usuall amongst the *Romanes*. To which that expression in \* *Salvian* may referre, where amongst other publick shewes of the Theater, he mentions the *Petaminarii*: which word (saith *J. Brascianus*) is scarce to be found in any other Authour, being not mentioned either in *Julius Pollux*, or *Politian*. 'Tis probably derived from the Greek word *πέταος*, which signifies to fly, and may refer to such kind of Rope-dancers.

But now because the arms extended, are but weak and easily wearied, therefore the motions by them are like to be but short and slow, answerable it may be to the flight of such domestic fowl, as are most conversant on the ground, which of themselves we see are quickly weary, and therefore much more would the arm of a man, as being not naturally designed to such a motion.

It were therefore worth the inquiry



ry to consider whether this might not be more probably effected by the labour of the feet, which are naturally more strong and indefatigable: In which contrivance the wings should come down from the shoulders on each side as in the other, but the motion of them should be from the legs, being thrust out and drawn in again one after another, so as each leg should move both wings, by which means a man should (as it were) walk or climbe up into the air: and then the hands and armes might be at leisure to help and direct the motion, or for any other service proportionable to their strength. Which conjecture is not without good probability, and some speciall advantages above the other.

4 But the fourth and last way seems unto me altogether as probable, and much more usefull then any of the rest. And that is by a flying chariot, which may be so contrived as to carry a man within it; and though the strength of a spring might per-

P

haps

haps be serviceable for the motion of this engine, yet it were better to have it assisted by the labour of some intelligent mover as the heavenly orbs are supposed to be turned. And therefore if it were made big enough to carry sundry persons together, then each of them in their severall turns might successively labour in the causing of this motion; which thereby would be much more constant and lasting, then it could otherwise be, if it did wholly depend on the strength of the same person. This contrivance being as much to be preferred before any of the other, as swimming in a ship before swimming in the water.

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C A P. VIII.

*A resolution of the two chief difficulties that seem to oppose the possibility of a flying Chariot.*

**T**He chief difficulties against the possibility of any such contrivance may be fully removed in the resolution

tion of these two *Quæres.*

1. Whether an engine of such capacity and weight, may be supported by so thin and light a body as the air?

2. Whether the strength of the persons within it, may be sufficient for the motion of it?

1. Concerning the first; when *Callias* was required by the men of *Rhodes*, to take up that great *Helepolis*, brought against them by *Demetrius*, (as he had done before unto some lesse which he himself had made.) He answered that it could not be done. *Nonnulla enim sunt quæ in exemplaribus videntur similia, cum autem crescere cæperunt, dilabuntur.* Because those things that appear probable in lesser models, when they are encreased to a greater proportion, do thereby exceed the power of art. For example, though a man may make an instrument to bore a hole, an inch wide, or half an inch, and so lesse; yet to bore a hole of a foot wide, or two foot, is not so much as to be

*Vitruvius  
Archit. l.  
10.6.22.*

*So Rāmus  
Schol. Ma-  
them. l. 1.*

thought of. Thus, though the air may be able to uphold some lesser bodies, as those of birds, yet when the quantity of them is encreased to any great extension, it may justly be doubted, whether they will not exceed the proportion that is naturally required unto such kind of bodies.

To this I answer, that the engine can never be too big or too heavy, if the space which it possesses in the air, and the motive faculty in the instrument be answerable to its weight. That saying of *Callias* was but a groundlesse shift and evasion, whereby he did endeavour to palliate his own ignorance and disability. The utmost truth which seems to be implied in it, is this: That there may be some bodies of so great a bignesse, and gravity, that it is very difficult to apply so much force unto any particular instrument, as shall be able to move them.

Against the example it may be affirmed and easily proved, that it is equally possible to bore a hole of any bignesse,



bignesse, as well great as little, if we suppose the instrument, and the strength and the application of this strength to be proportionable; But because of the difficulty of these concurrent circumstances in those greater and more unusuall operations, therefore doe they falsly seem to be absolutely impossible.

So that the chief inference from this argument and example, doth imply only thus much, that it is very difficult to contrive any such motive power, as shall be answerable to the greatnesse and weight of such an instrument as is here discoursed of, which doth not at all impair the truth to be maintained; For if the possibility of such a motion be yeelded, we need not make any scruple of granting the difficultie of it; It is this must adde a glory to the invention; and yet this will not perhaps seem so very difficult to any one who hath but diligently observed the flight of some other birds, particularly of a Kite, how he will swim up and down

in the air, sometimes at a great height, and presently again lower, guiding himself by his train, with his wings extended without any sensible motion of them; and all this when there is only some gentle breath of air stirring without the help of any strong forcible wind. Now I say, if that fowl (which is none of the lightest) can so very easily move it self up and down in the air, without so much as stirring the wings of it: certainly then, it is not improbable, but that when all the due proportions in such an engine are found out, and when men by long practise have arrived to any skill and experience, they will be able in this (as well as in many other things) to come very near unto the imitation of nature.

*Sen. Nat.*  
*Qu. l. 3.*  
*c. 25.*

As it is in those bodies which are carried on the water, though they be never so big or so ponderous, (suppose equall to a City or a whole Island) yet they will always swim on the top, if they be but any thing lighter, then so much water

as

as is equall to them in bignesse: So likewise is it in the bodies that are carried in the air. It is not their greatnesse (though never so immense) that can hinder their being supported in that light element, if we suppose them to be extended unto a proportionable space of air. And as from the former experiments, *Archimedes* hath composed a subtil science in his Book, *De insidentibus humido*, concerning the weight of any heavy body, in reference to the water wherein it is, So from the particular triall of these other experiments, that are here inquired after, it is possible to raise a new science, concerning the extension of bodies, in comparison to the air, and motive faculties by which they are to be carried.

We see a great difference betwixt the severall quantities of such bodies, as are commonly upheld by the air; not onely little gnats, and flies, but also the Eagle and other fowl of vaster magnitude. *Cardan* and *Scaliger* doe unanimously affirm, that there is a

*Histor.*  
*Nov. Orb.*  
*l. 4. c. 37.*

bird amongst the Indians of so great a bignesse, that his beak is often used to make a sheath or scabbard for a sword. And *Acosta* tells us of a fowl in *Peru* called *Condores*, which will of themselves kill and eat up a whole Calf at a time. Nor is there any reason why any other body may not be supported and carried by the air, though it should as much exceed the quantity of these fowl, as they do the quantity of a flie.

*Marcus Polus* mentions a fowl in *Madagascar*, which he calls a *Ruck*, the feathers of whose wings are 12 paces, or threescore foot long, which can with as much ease, loop up an Elephant as our Kites do a Mouse. If this relation were any thing credible, it might serve as an abundant proof for the present quære. But I conceive this to be already so evident, that it needs not any fable for its further confirmation.

2. The other doubt was, whether the strength of the other persons within it, will be sufficient for the moving



moving of this engine? I answer, the main difficultie and labour of it will be in the raising of it from the ground; neer unto which, the earths attractive vigor, is of greatest efficacy. But for the better effecting of this, it may be helped by the strength of winds, and by taking its first rise from some mountain or other high place. When once it is aloft in the air, the motion of it will be easie, as it is in the flight of all kinde of birds, which being at any great distance from the earth, are able to continue their motion for a long time and way, with little labour or wearinesse.

'Tis certain from common relation and experience that many birds doe cross the seas for divers hundred miles together: sundry of them amongst us, which are of a short wing and flight, as Blackbirds, Nightingales, &c. do flie from us into *Germany*, and other remoter Countries. And Mariners do commonly affirm that they have found some fowl above six hundred miles from any land.

Now

*Tlin. l. 10.  
c. 23.*

Now if we should suppose these birds to labour so much in those long journies, as they doe when they flie in our sight and near the earth, it were impossible for any of them to passe so farre without resting. And therefore it is probable, that they do mount unto so high a place in the air, where the naturall heavinessse of their bodies does prove but little or no impediment to their flight ; Though perhaps either hunger, or the sight of ships, or the like accident, may sometimes occasion their descending lower, as we may ghesse of those birds, which Mariners have thus beheld, and divers others that have been drowned and cast up by the sea.

Whence it may appear, that the motion of this chariot ( though it may be difficult at the first ) yet will still be easier as it ascends higher, till at length it shall become utterly devoid of gravity, when the least strength will be able to bestow upon it a swift motion : as I have proved  
more

more at large in another discourse.

But then, ( may some object ) If it be supposed that a man in the æthereall air does lose his own heaviness, how shall he contribute any force towards the motion of this instrument ?

World in  
the Moon,  
c. 14.

I answer, The strength of any living creature in these external motions, is something really distinct from, and superadded unto its naturall gravity : as common experience may shew, not only in the impression of blows or violent motions, as a river hawk will strike a fowl with a far greater force, then the meer descent or heaviness of his body could possibly perform. But also in those actions which are done without such help, as the pinching of the finger, the biting of the teeth, &c. all which are of much greater strength then can proceed from the meer heaviness of those parts.

As for the other particular doubts, concerning the extream thinness, and coldness of this æthereall air, by reason of which, it may seem to be al-

altogether impassible, I have already resolved them in the above cited discourse.

The uses of such a Chariot may be various: besides the discoveries which might be thereby made in the lunar world; It would be serviceable also for the conveyance of a man to any remote place of this earth: as suppose to the *Indies* or *Antipodes*. For when once it was elevated for some few miles, so as to be above that orb of magnetick virtue, which is carried about by the earths diurnall revolution, it might then be very easily and speedily directed to any particular place of this great Globe.

If the place which we intended were under the same parallel, why then the earths revolution once in twenty four houres, would bring it to be under us, so that it would be but descending in a straight line, and we might presently be there. If it were under any other parallel, it would then only require that we should direct it in the same Meridian, till we did come to that paral-



parallel ; and then ( as before ) a man might easily descend unto it.

It would be one great advantage in this kind of travelling, that one should be perfectly freed from all inconveniences of wayes or weather, not having any extremity of heat, or cold, or Tempests to molest him. This æthereall air being perpetually in an equall temper and calmnesse. *Pars*

*superior mundi ordinatio est nec in nubem cogitur, nec in tempestatem impellitur, nec versatur in turbinem, omnium tumultu caret, inferiora fulminant.*

The upper parts of the world are alwayes quiet and serene, no winds and blustering there, they are these lower cloudy regions that are so full of tempests and combustion.

As for the manner how the force of a spring, or ( in stead of that ) the strength of any living person, may be applyed to the motion of these wings of the Chariot, it may easily be apprehended from what was formerly delivered.

There are divers other particulars

to

*Sen. de Ira  
l. 3. c. 6.  
Pacem  
summa te-  
rent. Lu-  
can.*

As well  
too long  
as too  
short, too  
broad as  
too nar-  
row, may  
be an im-  
pediment  
to the mo-  
tion, by  
making it  
more dif-  
ficult, slow  
and flag-  
ging.

to be more fully enquired after, for the perfecting of such a flying Chariot ; as concerning the proportion of the wings both for their length and breadth , in comparison to the weight which is to bee carried by them, as also concerning those special contrivances, whereby the strength of these wings may be severally applied either to ascent, descent , progressive, or a turning motion ; All which, and divers the like enquiries can onely be resolved by particular experiments. We know the invention of sayling in ships does continually receive some new addition from the experience of every age, and hath been a long while growing up to that perfection, unto which it is now arrived. And so must it be expected for this likewise, which may at first perhaps seem perplexed with many difficulties and inconveniencies, and yet upon the experience of frequent tryals, many things may be suggested to make it more facil and commodious.

He

He that would regularly attempt any thing to this purpose, should observe this progresse in his experiments, he should first make enquiry what kind of wings would be most usefull to this end; those of a Bat being most easily imitable, and perhaps nature did by them purposely intend some intimation to direct us in such experiments; that creature being not properly a bird, because not amongst the *Ovipara*, to imply that other kind of creatures are capable of flying as well as birds, and if any should attempt it, that would be the best pattern for imitation.

After this he might try what may be effected by the force of springs in lesser models, answerable unto *Archytas* his Dove, and *Regiomontanus* his Eagle: In which he must be carefull to observe the various proportions betwixt the strength of the spring, the heaviness of the body, the breadth of the wings, the swiftnesse of the motion, &c.

From these he may by degrees ascend to some larger essays.

CAP.

## CAP. IX.

*Of a perpetuall motion. The seeming facility and reall difficulty of any such contrivance. The severall wayes whereby it hath been attempted, particularly by Chymistry.*

**I**T is the chief inconvenience of all the *Automata* before mentioned, that they need a frequent repair of new strength, the causes whence their motion does proceed, being subject to fail and come to a period; and therefore it would be worth our enquiry, to examine, whether or no there may be made any such artificiall contrivance, which might have the principle of moving from it self: so that the present motion should constantly be the cause of that which succeeds.

This is that great secret in art, which like the Philosophers stone in nature, hath been the businesse and study of many more refined wits, for divers ages together; and it may well be questioned, whether either

. of



of them as yet, hath ever been found out, though if this have, yet like the other, it is not plainly treated of by any Authour.

Not but that there are sundry discourses concerning this subject, but they are rather *conjectures* then *experiments*. And though many inventions in this kind, may at first view bear a great shew of probability, yet they will fail being brought to triall, and will not answer in practise what they promised in speculation. Any one who hath been versed in these experiments must needs acknowledge that he hath been often deceived in his strongest confidence; when the imagination hath contrived the whole frame of such an instrument, and conceives that the event must fallibly answer its hopes; yet then, does it strangely deceive in the proof, and discovers to us some defect, which we did not before take notice of.

Hence it is, that you shall scarce talk with any one who hath never so little smattering in these arts, but he

Q will

will instantly promise such a motion, as being but an easie atchievement. till further triall and experience hath taught him the difficulty of it. There being no enquiry that does more entice with the *probability*, and deceive with the *subtily*. What one speaks wittily concerning the Philosophers stone, may be justly applyed to this, that it is *Castam eretrix*, a chaste whore. *Quia multos invitat, neminem admittit*, because it allures many, but admits none.

I shall briefly recite the severall wayes whereby this hath been attempted, or seems most likely to be effected, thereby to contract and facilitate the enquiries of those who are addicted to these kind of experiments; for when they know the defects of other inventions, they may the more easily avoid the same, or the like, in their own.

The wayes whereby this hath been attempted, may be generally reduced to these three kinds:

1. By Chymicall extractions.

2. By

2. By Magneticall virtues.

3. By the naturall affection of gravity.

1. The discovery of this hath been attempted by Chymistry. *Paracelsus* and his followers have bragged, that by their separations and extractions, they can make a little world which shall have the same perpetuall motions with this *Microcosme*, with the representation of all Meteors, Thunder, snow, rain, the courses of the sea in its ebbs and flowes, and the like; But these miraculous promises would require as great a faith to believe them, as a power to perform them: And though they often talk of such great matters,

*At nusquam totos inter qui talia curant,*

*Apparet ullus, qui re miracula tanta  
Comprobet--*

yet we can never see them confirmed by any reall experiment; and then besides, every particular Authour in that art, hath such a distinct language of his own, (all of them being so full

of allegories and affected obscurities) that 'tis very hard for any one (unlesse he be thoroughly versed amongst them) to find out what they mean, much more to try it.

*Etten Ma-  
them. Re-  
creat prob.  
118.*

One of these wayes (as I finde it set down) is this. Mixe five ounces of  $\varphi$ , with an equall weight of  $\Psi$ , grinde them together with ten ounces of sublimate, dissolve them in a Cellar upon some marble for the space of four dayes, till they become like oyl olive; distill this with fire of chaffe, or driving fire, and it will sublime into a dry substance: and so by repeating of these dissolvings and distillings, there will be at length produced divers small atomes, which being put into a glasse well luted, and kept dry, will have a perpetuall motion.

I cannot say any thing from experience against this; but me thinks it does not seem very probable, because things that are forced up to such a vigoroussesse and activity, as these ingredients seem to be by their frequent



quent sublimatings and distillings, are not likely to be of any duration; the more any thing is stretched beyond its usuall nature, the lesse does it last, violence and perpetuity being no companions. And then besides, suppose it true, yet such a motion could not well be applied to any use, which must needs take much from the delight of it.

Amongst the Chymicall experiments to this purpose may be reckoned up that famous motion invented by *Cornelius Dreble*, and made for King *James*; wherein was represented the constant revolutions of the Sun and Moon, and that without the help either of spring or weights. *Marcellus Vranckhein*, speaking of the means whereby it was performed, he calls it, *Scintillula animæ magnetica mundi, seu Astralis & insensibilis spiritus*; being that grand secret, for the discovery of which, those Dictators of Philosophy, *Democritus*, *Pythagoras*, *Plato*, did travell unto the *Gymnosophists*, and *Indian Priests*.

Q 3

The

Celebrated  
in an Epi-  
gram by  
*Hugo Gro-  
tius l. 1.*  
*Epi. Epist.*  
*ad Ernestū  
de Lamp.*  
*Vix.*

Epist. ad  
Jacobum  
Regem.

Philosophical dia-  
logue.  
Confer. 2  
cap. 3.

The Author himself in his discourse upon it, does not at all reveal the way, how it was performed. But there is one *Thomas Tymme*, who was a familiar acquaintance of his, and did often pry into his works, (as he professes himself) who affirms it to be done thus; *By extracting a fiery spirit out of the Mineral matter, joyning the same with his proper air, which included in the Axle tree (of the first moving wheel) being hollow, carrieth the other wheels, making a continual rotation, except issue or vent be given in this hollow axle-tree, whereby the imprisoned spirit may get forth.*

What strange things may be done by such extractions, I know not, and therefore dare not condemn this relation as impossible; but me thinks it sounds rather like a chymicall dream, then a Philosophicall truth. It seems this imprisoned spirit is now set at liberty, or else is grown weary, for the instrument (as I have heard) hath stood still for many years. It is here considerable that any force is weakest

near

near the center of a wheel; and therefore though such a spirit might of it self have an agitation, yet 'tis not easily conceivable how it should have strength enough to carry the wheels about with it. And then the absurdity of the Authours citing this, would make one mistrust his mistake; he urges it as a strong argument against *Copernicus*, as if because *Dreble* did thus contrive in an Engine, the revolution of the heavens, and the immoveableness of the earth, therefore it must needs follow, that 'tis the heavens which are moved, and not the earth. If his relation were no truer then his consequence, it had not been worth the citing.

## CAP. X.

*Of subterraneous lamps, divers historical relations concerning their duration for many hundred years together.*

UNTo this kind of Chymicall experiments, we may most probably reduce those perpetuall lamps, which for many hundred years together have continued burning without any new supply in the sepulchres of the Ancients, and might (for ought we know) have remained so for ever. All fire, and especially flame, being of an active and stirring nature, it cannot therefore subsist without motion; whence it may seem, that this great enquiry hath been this way accomplished: and therefore it will be worth our examination to search further into the particulars that concern this experiment. Though it be not so proper to the chief purpose of this discourse, which concerns *Mechanicall Geometry*, yet the subtilty and



and curiosity of it, may abundantly requite the impertinency.

There are sundry Authors, who treat of this Subject on the by, and in some particular passages, but none that I know of (except *Fortunius Licetus*) that hath writ purposely any set and large discourse concerning it: out of whom I shall borrow many of those relations and opinions, which may most naturally conduce to the present enquiry.

For our fuller understanding of this, there are these particulars to be explained:

- { 1.  $\delta\tau\iota$ , or *quod sit*.  
    *cur sit*.  
 { 2.  $\delta\iota\omicron\tau\iota$  } *quomodo sit*.

1. First then, for the  $\delta\tau\iota$ , or that there have been such lamps, it may be evident from sundry plain and undeniable testimonies: Saint *Austin* mentions one of them in a Temple dedicated to *Venus*, which was always exposed to the open weather, and could never be consumed or extinguished. To him assents the judicious

*Lib. de re-  
conditiis an-  
tiquorum  
lucernis.*

*De civitat.  
Dei l. 21.  
cap. 6.*

*De operibus  
Dei part 1.  
J. 4. c. 12.  
De deperd.  
Tit. 35.*

\*Or *Anti-  
och Licetus  
de Lucer-  
nis, l. 16. 7.*

ous *Zanchy*. *Pancyröllus* mentions a Lamp found in his time, in the sepulchre of *Tullia*, *Cicero's* daughter, which had continued there for about 1550 years but was presently extinguished upon the admission of new air. And 'tis commonly related of *Cedrenus*, that in *Fustinians* time there was another burning lamp found in an old wall at \* *Edeffa*, which had remained so for above 500 years, there being a crucifixe placed by it, whence it should seem, that they were in use also amongst some Christians.

But more especially remarkable, is that relation celebrated by so many Authors, concerning *Olybins* his lamp, which had continued burning for 1500 years. The storie is thus : As a rustick was digging the ground by *Padua*, he found an Urne or earthen pot, in which there was another urne, and in this lesser, a lamp clearly burning; on each side of it, there were two other Vessels, each of them full of a pure liquor, the one of gold, the other of silver. *Ego Chymia artis, (si modo*

*modo vera potest esse ars Chymia*) jurare  
*ausim elementa & materiam omnium,*  
 (saith *Maturantius*, who had the pos-  
 session of these things after they were  
 taken up.) On the bigger of these  
 Urns there was this inscription :

*Plutoni sacrum munus ne attingite fures.*

*Ignotū est vobis hoc quod in orbe latet,*  
*Namque elementa gravi clausit digesta*  
*labore*

*Vase sub hoc modico, Maximus Oly-*  
*bius.*

*Adsit facundo custos sibi copia cornu,*  
*Ne tanti pretium depereat laticis.*

The lesser Urn was thus inscribed:

*Abite hinc pessimi fures,*

*Vos quid vultis, vestris cum oculis*  
*emissitiis ?*

*Abite hinc, vestro cum Mercurio*

*Petāsato Caduceatoque,*

*Donum hoc Maximum, Maximus Oly-*  
*bius*

*Plutoni sacrum facit.*

Whence we may probably conje-  
 cture that it was some Chymicall se-  
 cret,

Mag. Na-  
tural. l. 12.  
c. ult.

cret, by which this was contrived.

*Baptista Porta* tells us of another lamp burning in an old marble sepulchre, belonging to some of the ancient Romans, inclosed in a glasse viall, found in his time, about the year 1550, in the Isle *Nefis*, which had been buried there before our Saviours coming.

Chron.  
Martin  
Fort. Licet.  
de lucern.  
l. 1. c. 11.

In the Tombe of *Pallas* the Arcadian who was slain by *Turnus* in the Trojan war, there was found another burning lamp in the year of our Lord 1401. Whence it should seem, that it had continued there for above two thousand and six hundred years: and being taken out, it did remain burning, notwithstanding either wind or water, with which some did strive to quench it; nor could it be extinguished till they had spilt the liquor that was in it.

Not. ad  
August. de  
civit. Dei,  
l. 21. c. 6.

*Ludovicus Vives* tels us of another lamp that did continue burning for 1050 years, which was found a little before his time.

Such a lamp is likewise related to be



be seen in the sepulchre of *Francis Roscrosse*, as is more largely expressed in the confession of that fraternity.

There is another relation of a certain man, who upon occasion digging somewhat deep in the ground, did meet with something like a dore, having a wall on each hand of it; from which having cleared the earth, he forced open the door, upon this there was discovered a fair Vault, and towards the farther side of it, the statue of a man in Armour, sitting by a table, leaning upon his left arm, and holding a scepter in his right hand, with a lamp burning before him; the floor of this Vault being so contrived, that upon the first step into it, the statue would erect it self from its leaning posture; upon the second step it did lift up the scepter to strike, and before a man could approach near enough to take hold of the lamp, the statue did strike and break it to pieces: such care was there taken that it might not be stoln away, or discovered.

Our learned *Cambden* in his description

*Pag. 572.*

tion of *Yorkshire*, speaking of the tombe of *Constantius Chlorus*, broken up in these later years, mentions such a lamp to be found within it.

*De jure  
manium, l.  
2. c. 32.*

There are sundry other relations to this purpose. *Quod ad lucernas attinet, illa in omnibus fere monumentis inveniuntur*, (saith *Gutherius*.) In most of the ancient Monuments there is some kind of lamp, (though of the ordinary sort;) But those persons who were of greatest note and wisdom, did procure such as might last without supply, for so many ages together. *Pancirollus* tels us that it was usuall for the Nobles amongst the Romans, to take speciall care in their last wils, that they might have a lamp in their Monuments. And to this purpose they did usually give liberty unto some of their slaves on this condition, that they should be watchfull in maintaining and preserving it. From all which relations, the first particular of this enquiry, concerning the being or existence of such lamps, may sufficiently appear.

*De perdit.  
Tit. 62.*

## CAP. XI.

*Severall opinions concerning the nature  
and reason of these perpetuall Lamps.*

**T**Here are two opinions to be answered, which doe utterly overthrow the chief consequence from these relations.

1. Some think that these lights so often discovered in the ancient tombs, were not fire or flame, but onely some of those bright bodies which do usually shine in dark places.

2. Others grant them to be fire, but yet think them to be then first enkindled by the admission of new air, when these sepulchres were opened.

1. There are divers bodies (saith *Aristotle*) which shine in the dark, as rotten wood, the scales of some fishes, stones, the glow-worm, the eyes of divers creatures. *Cardan* tels us of a bird in new *Spain*, called *Cocoyum*, whose whole body is very bright, but his eyes almost equall to the light of

*De anima,*  
*l. 2. c. 7.*

*Subtil. l. 9.*

a candle, by which alone in a dark night, one may both write and read; By these the Indians (saith he) use to eat their feasting Suppers.

\* Carbo  
Pyropus.  
Historia  
Animal. l. 8

De Lapid.  
& Gemmis.  
l. 2. c. 8.

It is commonly related and believed, that a Carbuncle does shine in the dark like a burning coal, from whence it hath its \* name. To which purpose there is a story in *Ælian*, of a Stork, that by a certain woman was cured of a broken thigh, in gratitude to whom, this fowl afterwards flying by her, did let fall into her lap a bright Carbuncle, which (saith he) would in the night time shine as clear as a lamp. But this and the like old relations are now generally disbeleaved and rejected by learned men: *Doctissimorum omnium consensu, hujusmodi gemma non inveniuntur*, (saith *Boetius de Boot*) a man very much skilled in, and inquisite after such matters; nor is there any one of name that does from his own eye-sight or experience, affirm the reall existence of any gem so qualified.

Some have thought that the light  
in



in ancient tombs hath been occasioned from some such bodies as these. For if there had been any possibility to preserve fire so long a space, 'tis likely then that the *Israelites* would have known the way, who were to keep it perpetually for their sacrifices.

*Vide Licet. de lucern. l. 2.*

But to this opinion it might be replied, that none of these *Nocticula*, or night-shining bodies have been observed in any of the ancient sepulchres, and therefore this is a meer imaginary conjecture; And then besides, some of these lamps have been taken out burning, and continued so for a considerable space afterwards. As for the supposed conveniency of them, for the perpetuating of the holy fire amongst the Jewes, it may as well be feared lest these should have occasioned their idolatry; unto which that nation was so strongly addicted, upon every slight occasion; nor may it seem strange, if the providence of God should rather permit this fire sometimes to go out, that so by their earnest prayers, being a-

R

gain

\* Levit. 9.

24.

2 Chron.

7. 1.

1 King. 18.

38

*De jure**Mani. l. 2.*

c. 32.

gain renewed from heaven, ( as it \* sometimes was ) the peoples faith might be the better fired up and strengthened, by such frequent miracles.

2. It is the opinion of *Gutherius*, that these lamps have not continued burning for so long a space, as they are supposed in the former relations, but that they were then first enflamed by the admission of new air, or such other occasion, when the sepulchres were opened: as we see in those fat earthy vapours of divers sorts, which are oftentimes enkindled into a flame. And 'tis said, that there are some Chymicall wayes, whereby iron may be so heated, that being closely luted in a glasse, it shall constantly retain the fire for any space of time, though it were for a thousand years or more; at the end of which, if the glasse be opened, and the fresh air admitted, the iron shall be as red hot as if it were newly taken out of the fire.

But for answer to this opinion, 'tis considerable that some urns have had inscrip-

inscriptions on them, expressing that the lamps within them were burning, when they were first buried. To which may be added the experience of those which have continued so, for a good space afterwards; whereas the inflammation of fat and viscous vapours does presently vanish. The lamp which was found in the Isle *Nefis*, did burn clearly while it was inclosed in the glasse, but that being broken, was presently distinguished. As for that Chymicall relation, it may rather serve to prove, that fire may continue so many ages, without consuming any fewell.

So that notwithstanding the opposite opinions, yet 'tis more probable that there have been such lamps, as have *remained burning*, without any new supply, for many hundred years together; which was the first particular to be explained.

2. Concerning the reason, why the Ancients were so carefull in this particular, there are divers opinions. Some think it to be an expression of

*Curios.*

their belief, concerning the souls immortality, after its departure out of the body, a lamp amongst the *Egyptians* being the *Hieroglyphick* of life. And therefore they that could not procure such lamps, were yet carefull to have the image and representation of them ingraven on their Tombs.

Others conceive them to be by way of gratitude to those infernall deities, who took the charge and custody of their dead bodies, *remaining* alwayes with them in their Tombs, and were therefore called *Dii manes*.

Others are of opinion, that these lamps were onely intended to make their sepulchres more pleasant and lightsome, that they might not seem to be imprisoned in a dismall and uncomfortable place. True indeed, the dead body cannot be sensible of this light, no more could it of its want of buriall; yet the same instinct which did excite it to the desire of one, did also occasion the other.

*De Lucernis*, l. 3. c. 8.

*Licetus* concludes this ancient custom to have a double end. I. *Politick*,



*litick*, for the distinction of such as were nobly born, in whose monuments only they were used. 2. *Natural*, to preserve the body and soul from darkness; For it was a common opinion amongst them, that the souls also were much conversant about those places where the bodies were buried.

## CAP. XII.

*The most probable conjecture how these lamps were framed.*

THE greatest difficulty of this enquiry doth consist in this last particular, concerning the manner how, or by what possible means any such perpetual flame may be contrived.

*Quomodo  
fuit.*

For the discovery of which, there are two things to be more especially considered.

1. The snuffe or wick, which must administer unto the flame.

2. The oyl, which must nourish it.

For the first, it is generally granted that there are divers substances which will retain fire without consuming : such is that minerall which they call the Salamanders-wool, saith our learned \* Bacon. *Ipse expertus sum villos Salamandra non consumi*, saith † Joachim Fortius. And \* Wecker from his own knowledge affirms the same of *plume-allum*, that being formed into the likenesse of a wick, will administer to the flame, and yet not consume it self. Of this nature likewise was that which the Ancients did call *linum vivum*, or *asbestinum* : of this they were wont to make garments, that were not destroyed, but purified by fire ; and whereas the spots or foulness of other cloaths are washed out, in these they were usually burnt away. The bodies of the ancient Kings were wrapped in such garments when they were put in the funerall-pile, that their ashes might be therein preserved, without the mixture of any other. The materials of them were not from any herb or vegetable,

\* Nat. hist.  
exper. 774.

† Lib. ex  
per.

\* De Secretis,  
l. 3. c. 2.

Or *Linum  
Carpasium.*  
*Pluta* ch;  
the *Oracul.*  
Hesecul.

Plin. Hist.  
l. 19. c. 1.

ble, as other textiles, but from a stone called *Amiantus*, which being bruised by a hammer, and its earthy nature shaken out, retains certain hairy substances, which may be spun and woven as hemp or flaxe. *Pliny* sayes, that for the preciousnesse of it, it did almost equall the price of pearls. *Pancirallus* tels us, that it was very rare and esteemed precious in ancient times, but now is scarce found or known in any places, and therefore he reckons it amongst the things that are lost. But *L. Vivis* affirms, that he hath often seen wicks made of it at *Paris*, and the same matter woven into a napkin at *Louvaine*, which was cleansed by being burnt in the fire.

'Tis probable from these various relations, that there was severall sorts of it, some of a more precious, other of a baser kinde, that was found in *Cyprus*, the deserts of *India*, and a certain Province of *Asia*: this being common in some parts of *Italy*, but is so short and brittle, that it cannot be spun into a thred. And

R 4

there-

*Deperd.*  
*Tit. 4.*

*In August.*  
*de civit.*  
*Dei l. 21.*  
*c. 6.*

De lapid.  
& gemmis,  
l. 2. c. 204.

therefore is usefull onely for the wicks of perpetuall lamps, saith *Boetius de Boot.* Some of this, or very like it, I have upon inquiry lately procured and experimented. But whether it be the stone *Asbestus*, or onely *plumellum*, I cannot certainly affirm. For it seems they are both so very like, as to be commonly sold for one another (saith the same Authour.) However it does truely agree in this common quality ascribed unto both, of being incombustible, and not consumable by fire: But yet there is this inconvenience, that it doth contract so much fuliginous matter from the earthy parts of the oyl, (though it was tryed with some of the purest oyl, which is ordinary to be bought) that in a very few dayes it did choak and extinguish the flame. There may possibly be some chymicall way so to purifie and defecate this oyl, that it shall not spend into a sooty matter.

However if the liquor be of a close and glutinous consistency, it may burn without any snuffe, as we see  
in



in Camphire, and some other bituminous substances. And it is probable that most of the ancient lamps were of this kind, because the exactest relations (to my remembrance) do not mention any that have been found with such wicks.

But herein will consist the greatest difficulty, to find out what invention there might be for their duration. Concerning which there are sundry opinions.

Saint *Austin* speaking of that lamp in one of the Heathen Temples, thinks that it might either be done by Magick, the Devill thinking thereby to promote the worship and esteem of that idoll to which it was dedicated, or else that the art of man might make it of some such material, as the stone *Asbestus*, which being once enkindled, will burn without being consumed. As others (saith he) have contrived as great a wonder in appearance, from the naturall virtue of another stone, making an iron-image seem to hang in the air, by rea-

*De civ. Dei*  
l. 21 c. 6.

*Zanch. de*  
*Operibus*  
*Dei, par. 1.*  
l. 4. c. 12.

reason of two load-stones, the one being placed in the ceiling, the other in the floor.

Others are of opinion that this may be effected in a hollow vessel, exactly luted or stopped up in all the vents of it. And then, if a lamp be supposed to burn in it, but for the least moment of time, it must continue so always, or else there would be a *Vacuum*, which nature is not capable of; If you ask, how it shall be nourished, it is answered, that the oyl of it being turned into smoak and vapours, will again be converted into its former nature; For otherwise, if it should remain rarified in so thin a substance, then there would not be room enough for that fume which must succeed it; and so on the other side, there might be some danger of the *penetration* of bodies, which nature doth as much abhor. To prevent both which, as it is in the chymicall circulations, where the same body is oftentimes turned from liquor into vapour, and from vapour into liquor again; so  
in

in this experiment, the same oyl shall be turned into fume, and that fume shall again convert into oyl. Always provided, that this oyl which nourishes the lamp, be supposed of so close and tenacious a substance, that may slowly evaporate, and so there will be the more leisure for nature to perfect these circulations. According to which contrivance, the lamp within this vessel can never fail, being always supplied with sufficient nourishment. That which was found in the Isle *Nefis*, inclosed in glasse viall, mentioned by *Baptista Porta*, is thought to be made after some such manner as this.

Others conceive it possible to extract such an oyl out of some minerals, which shall for a long space serve to nourish the flame of a lamp with very little or no expence of its own substance. To which purpose (say they) if gold be dissolved into an unctuous humour; or if the radicall moisture of that metall were separated, it might be contrived to burn  
(perhaps

*Wolfgang.  
Lazius, l. 3  
c. 18.  
Camb. Brit  
p. 572.*

(perhaps for ever, or at least) for many ages together, without being consumed. For if gold it self ( as experience shews ) be so untameable by the fire, that after many meltings, and violent heats, it does scarce diminish, 'tis probable then, that being dissolved into an oylie substance, it might for many hundred years together continue burning.

There is a little chymical discourse, to prove that *Urim* and *Thummim* is to be made by art ; the Author of this Treatise affirms that place, *Gen. 6. 16.* where God tells *Noah*, *a window shalt thou make in the Ark*, to be very unfitly rendred in our Translation a window, because the Original word צִנּוֹת signifies properly splendor or light ; and then besides the air being at that time so extreemly darkned with the clouds of that excessive rain, a window could be but of very little use in regard of light, unlesse there were some other help for it ; From whence he conjectures that both this splendor, and so likewise the *Urim* and



and Thummin were artificiall, chymicall preparations of light, answerable to these subterraneous lamps; or in his own phrase, it hath *the universall spirit fixed in a transparent body.*

It is the opinion of *Licetus* ( who hath more exactly searched into the subtilties of this enquiry ) that fire does not need any humour for the nourishment of it, but onely to detain it from flying upwards. For being it self one of the chief elements (saith he out of *Theophrastus*) it were absurd to think that it could not subsist without something to feed it. As for that substance which is consumed by it, this cannot be said to foment or preserve the same fire, but onely to generate new. For the better understanding of this, we must observe, that there may be a threefold proportion betwixt fire, and the humour or matter of it. Either the humour does exceed the strength of the fire, or the fire does exceed the humour; and according to both these, the flame doth presently vanish. Or  
else

*De Lucernis, c. 20, 21*

else lastly, they may be both equall in their virtues, (as it is betwixt the radicall moisture and naturall heat in living creatures) and then neither of them can overcome or destroy the other.

Those ancient lamps of such long duration were of this later kind. But now, because the qualities of heat or cold, drinesse or moisture in the ambient air, may alter this equality of proportion betwixt them, and make one stronger then the other; therefore to prevent this, the Ancients did hide these lamps in some caverns of the earth, or close montiments: And hence is it, that at the opening of these, the admission of new air unto the lamp does usually cause so great an inequality betwixt the flame and the oyl, that it is presently extinguished.

But still the greatest difficulty remains, how to make any such exact proportion betwixt an unctuous humour, and such an active quality, as the heat of fire, or this equality being

ing made, it is yet a further difficulty, how it may be preserved. To which purpose, *Licetus* thinks it possible to extract an inflammable oyl from the stone *Asbestus*, *Amiantus*, or the metall-gold, which being of the same pure and homogeneous nature with those bodies, shall be so proportioned unto the heat of fire, that it cannot be consumed by it, but being once inflamed should continue for many ages, without any sensible diminution.

If it be in the power of Chymistry to perform such strange effects, as are commonly experimented in that which they call *aurum fulminans*, one scruple of which shall give a lowder blow, and be of greater force in descent, then half a pound of ordinary gun-powder in ascent; why may it not be as feasible by the same art to extract such an oyl as is here enquired after: Since it must needs be more difficult to make a fire which of its own inclination shall tend downwards, then to contrive such an un-

Quous

etuous liquor, wherein fire shall be maintained for many years without any new supply.

Thus have I briefly set down the relations and opinions of divers learned men concerning these perpetuall lamps, of which, though there have been so many sundry kinds, and severall wayes to make them, ( some being able to resist any violence of weathers, others being easily extinguished by any little alteration of the air, some being inclosed round about within glasse, others being open ; ) yet now they are all of them utterly perished amongst the other ruines of time ; and those who are most versed in the search after them have onely recovered such dark conjectures, from which a man cannot clearly deduce any evident principle that may encourage him to a particular triall.



## CAP. XIII.

*Concerning severall attempts of contriving a perpetuall motion by magneticall virtues.*

THE second way whereby the making of a perpetuall motion hath been attempted, is by magneticall virtues; which are not without some strong probabilities of proving effectuall to this purpose: especially when we consider that the heavenly revolutions, (being as the first pattern imitated and aimed at in these attempts) are all of them performed by the help of these qualities. This great orb of earth, and all the other planets being but as so many magneticall globes endowed with such various and continuall motions, as may be most agreeable to the purposes for which they were intended. And therefore most of the Authours, who treat concerning this invention, do agree, that the likeliest way to effect it, is by these kind of qualities.

S

It

Gilbert de  
Magnet.  
Caus  
Philos.  
Magnet.  
l. 4. c. 20.

Athanas.  
Kircher. de  
Arte Mag-  
net. l. 1 par.  
2 prop. 13.  
Item l. 2.  
p. 4.

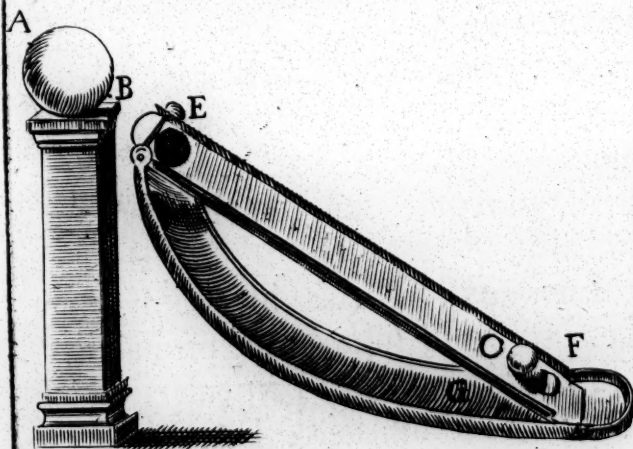
<sup>a</sup> Traët. de  
motu conti-  
nu.  
<sup>b</sup> De Rota  
perpetui  
motus par.  
2 c. 3.  
<sup>c</sup> De Va-  
riet. rerum  
l. 9 c. 48.  
Demog-  
net. l. 2.  
c. 35.

It was the opinion of *Pet. Peregrinus*, and there is an example pretended for it in *Bettinus* (*Apian. 9. Progym. 5. pro. 11.*) that a magneticall globe or terella, being rightly placed upon its poles, would of it self have a constant rotation, like the diurnall motion of the earth; But this is commonly exploded, as being against all experience.

Others think it possible, so to contrive severall pieces of steel, and a loadstone, that by their continuall attraction and expulsion of one another, they may cause a perpetuall revolution of a wheel; Of this opinion were <sup>a</sup> *Taisner*, <sup>b</sup> *Pet. Peregrinus*, and <sup>c</sup> *Cardan*, out of *Antonius de Fantis*. But *D. Gilbert*, who was more especially versed in magnetical experiments, concludes it to be a vain and groundlesse fancy.

But amongst all these kind of inventions, that is most likely, wherein a loadstone is so disposed, that it shall draw unto it on a reclined plane, a bullet of steel; which steel, as it a-  
scends

scends neer to the loadstone, may be contrived to fall down through some hole in the plane, and so to return unto the place from whence at first it began to move; and being there, the loadstone will again attract it upwards; till coming to this hole it will fall down again: and so the motion shall be perpetuall, as may be more easily conceivable by this figure.



S 2

Suppose

Suppose the loadstone to be represented at  $A B$ , which though it have not strength enough to attract the bullet  $C$ , directly from the ground, yet may do it by the help of the plane  $E F$ ; Now when the bullet is come to the top of this plane, its own gravity (which is supposed to exceed the strength of the loadstone) will make it fall into that hole at  $E$ : and the force it receives in this fall will carry it with such a violence unto the other end of this arch, that it will open the passage which is there made for it, and by its return will again shut it, so that the bullet, ( as at the first ) is in the same place whence it was attracted, and consequently must move perpetually.

But however this invention may seem to be of such strong probability, yet there are sundry particulars which may prove it sufficient; For,

1. This bullet of steel must first be touched and have its severall poles, or else there can be little or no attraction of it. Suppose  $C$  in the steel



to be answerable unto  $A$  in the stone, and to  $B$ ; In the attraction  $C D$ , must always be directed answerable to  $A B$ , and so the motion will be more difficult, by reason there can be no rotation or turning round of the bullet, but it must slide up with the line  $C D$ , answerable to the axis  $A B$ .

2. In its fall from  $E$  to  $G$ , which is *motus elementaris*, and proceeds from its gravity, there must needs be a rotation of it, and so 'tis odds, but it happens wrong in the rise, the poles in the bullet, being not in the same direction to those in the magnet; and if in this reflux it should so fall out, that  $D$  should be directed towards  $B$ , there should be rather a flight than an attraction, since those two ends do *repell* and not draw one another.

3. If the loadstone  $A B$ , have so much strength that it can attract the bullet in  $F$ , when it is not turned round, but does only slide upon the plane, whereas its own gravity would roul it downwards: then it is evident,

the sphere of its activity and strength would be so increased when it approaches much neerer, that it would not need the assistance of the plane, but would draw it immediately to it self, without that help, and so the bullet would not fall down through the hole, but ascend to the stone, and consequently cease its motion. For if the loadstone be of force enough to draw the bullet on the plane, at the distance  $F B$ , then must the strength of it be sufficient to attract it immediately unto it self, when it is so much neerer as  $E B$ . And if the gravity of the bullet be supposed so much to exceed the strength of the Magnet, that it cannot draw it directly when it is so near, then will it not be able to attract the bullet up the plane when it is so much further off.

So that none of all these Magnetical experiments, which have been as yet discovered, are sufficient for the effecting of a perpetual motion, though these kind of qualities seem most conducive unto it, and perhaps

haps hereafter it may be contrived from them.

## CAP. XIV.

*The seeming probability of effecting a continuall motion by solid weights in a hollow wheel or sphere.*

THE third way whereby the making of a perpetual motion hath been attempted, is by the naturall affection of gravity; when the heaviness of severall bodies is so contrived, that the same motion which they give in their descent, may be able to carry them up again.

But against the possibility of any such invention, it is thus objected by *Cardan*; All sublunary bodies have a direct motion either of ascent or descent, which, because it does refer to some term, therefore cannot be perpetual, but must needs cease, when it is arrived at the place unto which it naturally tends.

*Subtil.* 1. 17  
*De Var*  
*Rerum* 1. 9.  
c. 48.

I answer, though this may prove  
S 4 that

that there is no natural motion of any particular heavy body, which is perpetual, yet it doth not hinder but that it is possible from them to contrive such an artificial revolution as shall constantly be the cause of it self.

Those bodies which may be serviceable to this purpose, are distinguishable into two kinds.

1. Solid and consistent, as weights of metall, or the like.
2. Fluid or sliding, as water, sand, &c.

Both these ways have been attempted by many, though with very little or no successe. Other mens conjectures in this kind you may see set down by divers Authors. It would be too tedious to repeat them over, or set forth their draughts. I shall onely mention two new ones, which (if I am not over partial) seem altogether as probable as any of these kinds that have been yet invented; and till experience had discovered their defect and insufficiency, I did certainly

D. Fluid.  
*Pract* 2.  
 part 7 l. 2.  
 c. 4. & 7.



tainly conclude them to be infallible.

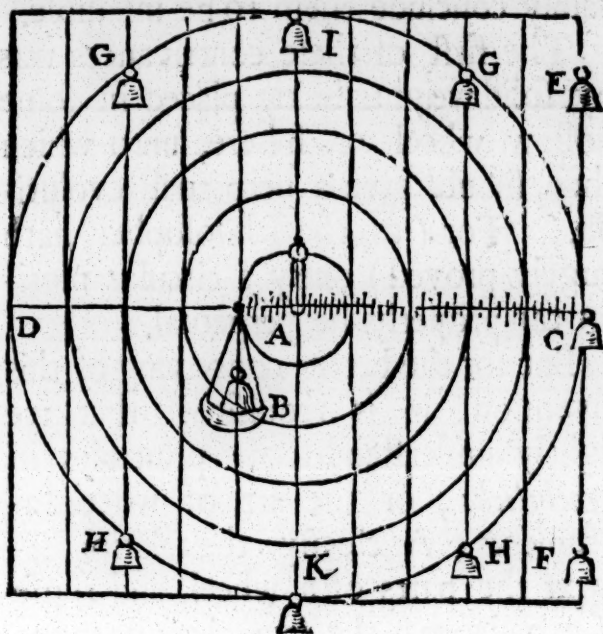
The first of these contrivances was by solid weights being placed in some hollow wheel or sphere, unto which they should give a perpetual revolution. For (as the Philosopher hath largely proved) onely a circular motion can properly be perpetual.

But for the better conceiving of this invention, it is requisite, that we rightly understand some principles in *Trochilicks*, or the art of wheel instruments; As chiefly, the relation betwixt the parts of a wheel, and those of a ballance; the several proportions in the Semidiameter of a wheel, being answerable to the sides in a ballance, where the weight is multiplied according to its distance from the center.

*Arist. Phys.*  
18. c. 12.

*Arist Me-*  
*chan. c. 2.*  
*De ratione*  
*libræ ad*  
*circulum.*

Thus



Thus suppose the center to be at *A*, and the Diameter of the wheel *DC*, to be divided into equal parts (as is here expressed) it is evident according to the former ground, that one pound at *C*, will equiponderate to five pound at *B*, because there is such a proportion betwixt their several distances from the Center. And it is not material whether or no these several weights be placed horizontally, for though *B* do hang lower then

then *C*, yet this does not at all concern the heaviness, or though the plummet *C*, were placed much higher then it is at *E*, or lower at *F*, yet would it still retain the same weight which it had at *C*, because these plummets (as is the nature of all heavy bodies) doe tend downwards by a straight line : So that their severall gravities are to be measured by that part of the horizontal Semidiameter, which is directly either below or above them. Thus when the plummet *C*, shall be moved either to *G* or *H*, it will lose  $\frac{2}{3}$  of its former heaviness, and be equally ponderous as if it were placed in the balance at the number 3, and if we suppose it to be situated at *I* or *K*, then the weight of it will lie wholly upon the Center, and not at all conduce to the motion of the wheel on either side. So that the straight lines which passe through the divisions of the diameter, may serve to measure the heaviness of any weight in its severall situations.

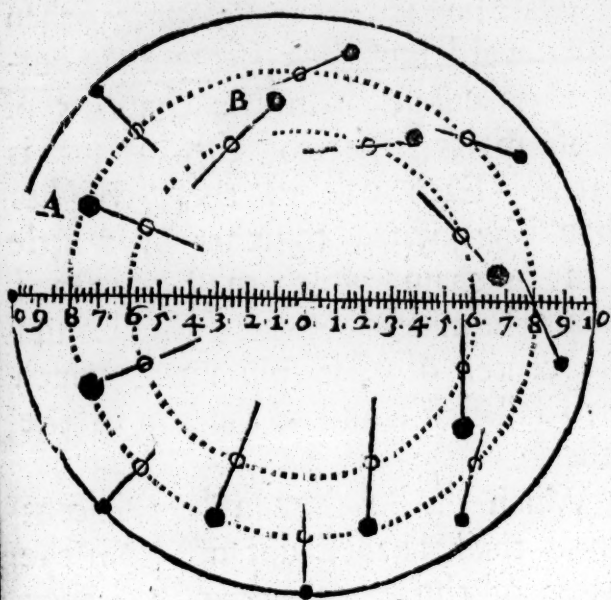
These things throughly considered,  
it

it seems very possible and easie for a man to contrive the plummets of a wheel, that they may be always heavier in their fall, then in their ascent, and so consequently that they should give a perpetual motion to the wheel it self: Since it is impossible for that to remain unmoved, as long as one side in it is heavier then the other.

For the performance of this, the weights must be so ordered, 1. That in their descent they may fall from the Center, and in their ascent may rise nearer to it. 2. That the fall of each plummet may begin the motion of that which should succeed it. As in this following Diagram.

Where





Where there are 16 plummets, 8 in the inward circle, and as many in the outward, (the inequality being to arise from their situation, it is therefore most convenient that the number of them be even.) The eight inward plummets are supposed to be in themselves so much heavier then the other, that in the wheel they may be of equall weight with those above them, and then the fall of these will be of sufficient force to bring down

down the other. For example, if the outward be each of them 4 ounces, then the inward must be 5, because the outward is distant from the center 5 of those parts, whereof the inward is but 4. Each pair of these weights should be joyned together by a little string or chain, which must be fastned about the middle betwixt the bullet and the center of that plummet, which is to fall first, and at the top of the other.

When these bullets in their descent are at their farthest distance from the center of the wheel, then shall they be stopped, and rest on the pins placed to that purpose; and so in their rising, there must be other pins to keep them in a convenient posture and distance from the center, lest approaching too neer unto it, they thereby become unfit to fall, when they shall come to the top of the descending side.

This may be otherwise contrived with some different circumstances, but they will all redound to the same effect.

effect. By such an engine it seems very probable, that a man may produce a perpetual motion. The distance of the plummets from the center increasing their weight on one side, and their being tyed to one another, causing a constant succession in their falling.

But now, upon experience I have found this to be fallacious, and the reason may sufficiently appear by a calculation of the heaviness of each plummet, according to its severall situation; which may easily be done by those perpendiculars that cut the diameter, (as was before explained, and is here expressed in five of the plummets on the descending side.) From such a calculation it will be evident, that both the sides of this wheel will equiponderate, and so consequently that the supposed inequality, whence the motion should proceed, is but imaginary and groundless. On the descending side, the heaviness of each plummet may be measured according to these numbers, (supposing the diameter

iameter of the wheel to be divided into twenty parts, and each of those subdivided into four.)

*The outward  
plummets.*

$$\left\{ \begin{array}{cc} 7 & 0 \\ 10 & 0 \\ 7 & 0 \end{array} \right\} \begin{array}{l} \textit{The sum} \\ 24. \end{array}$$

*The inward  
plummets.*

$$\left\{ \begin{array}{cc} 1 & 0 \\ 7 & 2 \\ 7 & 2 \\ 3 & 0 \end{array} \right\} \begin{array}{l} \textit{The sum} \\ 19 \end{array}$$

On the ascending side the weights are to be reckoned according to these degrees.

*The outward.*

$$\left\{ \begin{array}{cc} 1 & 3 \\ 7 & 2 \\ 9 & 0 \\ 5 & 3 \\ 0 & 0 \end{array} \right\} \begin{array}{l} \textit{The sum} \\ 24. \end{array}$$

*The inward.*

$$\left\{ \begin{array}{cc} 4 & 1 \\ 7 & 0 \\ 5 & 2 \\ 2 & 1 \end{array} \right\} \begin{array}{l} \textit{The sum} \\ 19 \end{array}$$

The summe of which last numbers is equall with the former, and therefore both the sides of such a wheel, in this situation will equi-ponderate.



If it be objected, that the plummet *A* should bee contrived to pull down the other at *B*, and then the descending side will be heavier then the other.

For answer to this, it is considerable,

1. That these bullets towards the top of the wheel, cannot descend till they come to a certain kind of inclination.

2. That any lower bullet hanging upon the other above it, to pull it down, must be conceived, as if the weight of it were in that point where its string touches the upper, at which point this bullet will be of lesse heaviness in respect of the wheel, then if it did rest in its own place: So that both the sides of it in any kind of situation may equiponderate.

## CAP. XV.

*Of composing a perpetuall motion by fluid weights. Concerning Archimedes his water-screw. The great probability of accomplishing this inquiry by the help of that: with the falliblenesse of it upon experiment.*

**T**Hat which I shall mention as the last way, for the triall of this experiment, is by contriving it in some water instrument; which may seem a'together as probable and easie as any of the rest, because that element by reason of its fluid and subtile nature (whereby of its own accord it searches out the lower and more narrow passages) may be most pliable to the mind of the artificer. Now the usuall means for the ascent of water is either by *Suckers* or *Forces*, or something equivalent thereunto; Neither of which may be conveniently applied unto such a work as this, because there is required unto each of them so much or more strength, as may be answerable

ble to the full weight of the water that is to be drawn up; and then besides, they move for the most part by fits and snatches, so that it is not easily conceivable, how they should conduce unto such a motion, which by reason of its perpetuity must bee regular and equall.

But amongst all other wayes to this purpose, that invention of *Archimedes* is in comparably the best, which is usually called *Cochlea*, or the *water-screw*, being framed by the helicall revolution of a cavity about a Cylinder. We have not any discourse from the Authour himself concerning it, nor is it certain whether he ever writ any thing to this purpose. But if he did, yet as the injury of time hath deprived us of many other his excellent works, so likewise of this, amongst the rest.

*Athenaus* speaking of that great ship built by *Hiero*, in the framing of which, there were 300. Carpenters employed for a year together, besides many other hirelings for carriages,

*Dipnosoph.*  
l. 5.

and such servile works, mentions this instrument as being instead of a pump for that vast ship, by the help of which, one man might easily and speedily drain out the water, though it were very deep.

*Biblioth.*  
*l. 1.*

*Diodorus Siculus* speaking of this engine, tels us, that *Archimedes* invented it when he was in *Ægypt*, and that it was used in that Country for the draining those pits and lower grounds, whence the waters of *Nilus* could not return. *Φιλοτέχνη δ' ὄντο τὰ ὀργανα καὶ ὑπερβολὴν*, (saith the same Authour.) It being an engine so ingenious and artificiall, as cannot be sufficiently expressed or commended. And so (it should seem) the Smith in Millain conceived it to be, who having without any teaching or information found it out, and therefore thinking himself to be the first inventer, fell mad with the meer joy of it.

*Cardan.*  
*subl. l. 1.*  
*De sapient.*  
*l. 5.*

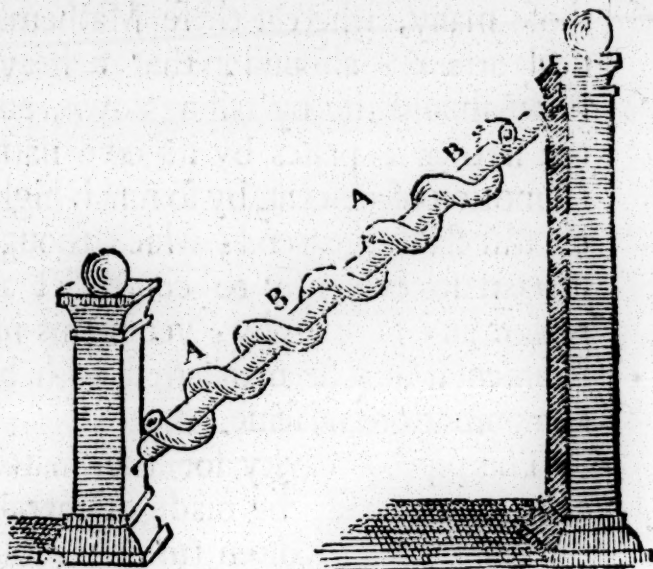
*Architect.*  
*l. 10. c. 11.*

The nature and manner of making this, is more largely handled by *Vitruius*.

The



The Figure of it is after this manner.!



Where you see there is a Cylinder *A A*, and a spirall cavity or pipe twining about it, according to equall revolutions *B B*. The axis and centers of its motions are at the points *C D*, upon which being turned, it will so happen that the same part of the pipe which was now lowermost, will presently become higher, so that the water does ascend by descending; ascending in comparifon to the whole instrument, and descending in respect

of its severall parts. This being one of the strangest wonders amongst those many, wherein these Mathematical arts do abound, that a heavy body should rise by falling down, and the farther it passes by its own natural motion of descent, by so much higher still shall it ascend; which though it seem so evidently to contradict all reason and Philosophy; yet in this instrument it may be manifested both by demonstration and sense.

This pipe or cavity for the matter of it, cannot easily be made of metall, by reason of its often turnings; but for trial, there might be such a cavity, cut in a column of wood, and afterwards covered over with tinplate.

For the form and manner of making this screw, *Vitruvius* does prescribe these two rules:

1. That there must be an equality observed betwixt the breadth of the pipe, and the distance of its several circumvolutions.
2. That there must be such a proportion

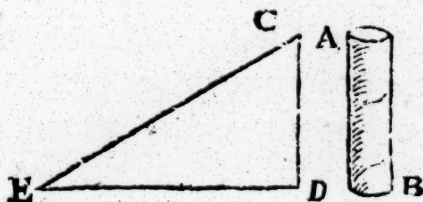
portion betwixt the length of the instrument, and its elevation, as is answerable to the *Pythagoricall Trigon*. If the Hypotenusall, or Screw be 5, the perpendicular or elevation must be 3, and the basis 4.

However (with his leave) neither of these proportions are generally necessary, but should be varied according to other circumstances. As for the breadth of the pipe in respect of its revolutions, it is left at liberty, and may bee contrived according to the quantity of water which it should contain. The chief thing to be considered is the obliquity or closeness of these circumvolutions. For the nearer they are unto one another, the higher may the instrument be erected; there being no other guide for its true elevation but this.

And because the right understanding of this particular is one of the principall matters that concern the use of this engine, therefore I shall endeavour with brevity and perspicuity to explain it. The first thing

David Ri-  
vall. Com.  
in Archim.  
opera. ex-  
tern.

to be inquired after is what kind of inclination these Helicall revolutions of the cylinder have unto the Horizon, which may be thus found out.

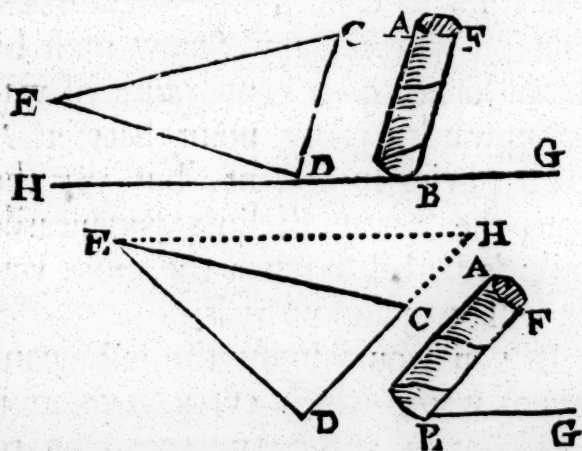


Let  $AB$  represent a Cylinder with two perfect revolutions in it, unto which cylinder the perpendicular line  $CD$  is equall: the basis  $DE$  being supposed to be double unto the compasse or circumference of the cylinder. Now it is certain that the angle  $CED$ , is the same with that by which the revolutions on the cylinder are framed, and that the line  $EC$ , in comparison to the basis  $ED$ , does shew the inclination of these revolutions unto the Horizon. The grounds and demonstration of this are more fully set down by *Guidus Ubaldus*, in his *Mechanicks*, and that other



other Treatise *De Cochlea*, which he writ purposely for the explication of this instrument, where the subtilties of it are largely and excellently handled.

Now if this Screw which was before perpendicular, be supposed to decline unto the Horizon by the angle  $F B G$ , as in this second Figure;



then the inclination of the revolutions in it, will be increased by the angle  $E D H$ , though these revolutions will still remain in a kind of ascent, so that water cannot be turned through them.

But

But now if the Screw be placed so far declining, that the angle of its inclination  $F B G$ , be lesse then the angle  $E C D$ , in the triangle, as in this other Diagram under the former; then the revolutions of it will descend to the Horizon, as does the line  $E C$ , and in such a posture, if the Screw be turned round, water will ascend through its cavity. Whence it is easie to conceive the certain declination wherein any Screw must be placed for its own conveyance of water upwards. Any point betwixt  $H$  and  $D$ , being in descent, but yet the more the Screw declines downwards towards  $D$ , by so much the more water will be carried up by it.

If you would know the just quantity of water which every revolution does contain and carry, according to any inclination of the cylinder, this may be easily found by ascribing on it an *Ellipsis*, parallel to the Horizon; which *Ellipsis* will shew how much of the revolution is empty, and how much full.

See a further explanation of this in *H-baldus de Cochlea*, l. 2. *Prop. 25.*

The

The true inclination of the Screw being found, together with the certain quantity of water which every *helix* does contain; it is further considerable, that the water by this instrument does ascend naturally of it self without any violence or labour, and that the heaviness of it doth lie chiefly upon the centers or axis of the cylinder, both its sides being of equall weight (saith *Ubaldu*;) So that (it should seem) though we suppose each revolution to have an equall quantity of water, yet the Screw will remain with any part upwards (according as it shall be set) without turning it self either way. And therefore the least strength being added to either of its sides, should make it descend, according to that common Maxime of *Archimedes*; any addition will make that which equiponderates with another, to tend downwards.

But now, because the weight of this instrument, and the water in it does lean wholly upon the axis,  
hence

*Ibid. l. 3.  
prop. 4.*

*De Equi-  
pond. Sup-  
pos. 3.*

hence is it (saith *Ubalduſ*) that the grating and rubbing of theſe axes againſt the ſockets wherein they are placed, will cauſe ſome ineptitude and reſiſtency to that rotation of the cylinder, which would otherwiſe enſue upon the addition of the leaſt weight to any one ſide; But (saith the ſame Author) any power that is greater then this reſiſtency which does ariſe from the axis, will ſerve for the turning of it round.

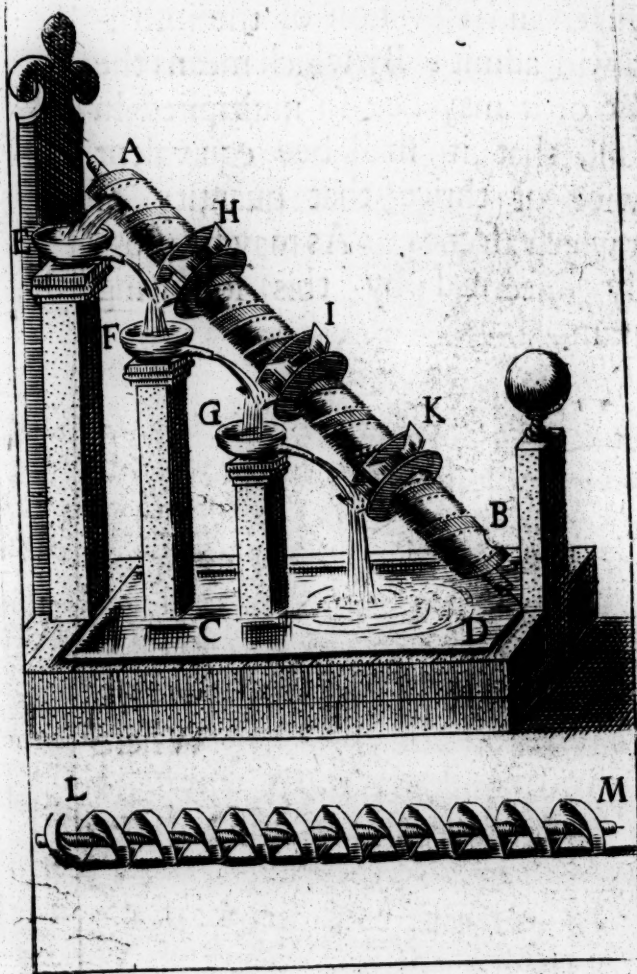
Theſe things conſidered together, it will hence appear, how a perpetual motion may ſeem eaſily contrivable. For if there were but ſuch a water-wheel made on this inſtrument, upon which the ſtream that is carried up, may fall in its deſcent it would turn the ſcrew round, and by that means convey as much water up, as is required to move it, ſo that the motion muſt needs be continual, ſince the ſame weight which in its fall does turn the wheel, is by the turning of the wheel carried up again.

Or if the water falling upon one wheel



wheel would not be forcible enough for this effect, why then there might be two or three, or more, according as the length and elevation of the instrument will admit; By which means the weight of it may bee so multiplied in the fall, that it shall bee equivalent to twice or thrice that quantity of water which ascends. As may be more plainly discerned by this following Diagram.

Where



Where the figure *LM*, at the bottom does represent a wooden cylinder with helicall cavities cut in it, which at *AB*, is supposed to be covered over within tin plates, and three water-wheels upon it *HIK*. The lower cistern which contains the water being *CD*. Now this cylinder being turned round, all the water which from the cistern ascends through it, will fall into the vessell at *E*, and from that vessell being conveyed upon the water wheel *H*, shall consequently give a circular motion to the whole Screw: Or if this alone should be too weak for the turning of it, then the same water which falls from the wheel *H*, being received into the other vessell *F*, may from thence againe descend on the wheel *I*; by which means the force of it will be doubled. And if this be yet insufficient, then may the water which falls on the second wheel *I*, be received into the other vessell *G*, and from thence again descend on the third wheel at *K*: and so for as many

There is another like contrivance to this purpose in *Pet: Bessin. Apiar. 4. Progm. 1. Prop. 10.* but with much lesse advantage then 'tis here proposed.

many other wheels, as the instrument is capable of. So that besides the greater distance of these three streams from the center or axis, by which they are made so much heavier, and besides, that the fall of this outward water is forcible and violent, whereas the ascent of that within is naturall ; Besides all this, there is thrice as much water to turn the Screw, as is carried up by it

But on the other side, if all the water falling upon one wheel, would be able to turn it round, then half of it would serve with two wheels ; and the rest may be so disposed of in the fall, as to serve unto some other usefull delightfull ends.

When I first thought of this invention, I could scarce forbear with *Archimedes* to cry out *εὐρηκα εὐρηκα* ; It seeming so infallible a way for the effecting of a perpetuall motion, that nothing could bee so much as probably objected against it : But upon triall and experience I find it altogether insufficient for any such purpose



purpose, and that for these two reasons:

1. The water that ascends will not make any considerable stream in the fall.

2. This stream (though multiplyed) will not be of force enough to turn about the Screw.

1. The water ascends gently and by intermissions, but it falls continually and with force; each of the three vessels being supposed full at the first, that so the weight of the water in them might adde the greater strength and swiftnesse to the streams that descend from them; Now this swiftnesse of motion will cause so great a difference betwixt them, that one of these little streams may spend more water in the fall, then a stream six times bigger in the ascent, though we should suppose both of them to be continue; How much more then, when as the ascending water is vented by fits and intermissions, every circumvolution voiding onely so much as is con-

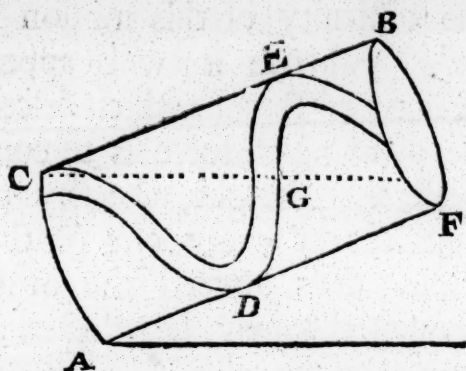
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tained in one *Helix*? And in this particular, one that is not versed in these kind of experiments, may be easily deceived.

But secondly, though there were so great a disproportion, yet notwithstanding the force of these outward streams, might well enough serve for the turning of the Screw, if it were so that both its sides would equiponderate the water being in them (as *Ubaldu*s hath affirmed.) But now upon farther examination, we shall find this assertion of his, to be utterly against both reason and experience. And herein does consist the chief mistake of this contrivance. For the ascending side of the Screw is made by the water contained in it so much heavier than the descending side, that these outward streams thus applyed, will not be of force enoug to make them equiponderate, much lesse to move the whole. As may be more easily discerned by this figure.

Where



Where  $A B$ , represents a Screw covered over,  $C D E$ , one *Helix* or revolution of it,  $C D$ , the ascending side,  $E D$  the descending side, the point  $D$  the middle. The Horizontal line  $C F$ , shewing how much of the *Helix* is filled with water, *viz.* of the ascending side, from  $C$  the beginning of the *Helix* to  $D$  the middle of it; and on the descending side, from  $D$  the middle, to the point  $G$ , where the Horizontal does cut the *Helix*. Now it is evident that this latter part  $D G$ , is nothing near so much, and consequently not so heavy as the other  $D C$ . And thus is it in all the other revolutions, which as they are either more or larger, so

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will

will the difficulty of this motion be increased. Whence it will appear, that the outward streams which descend must be of so much force as to countervail all that weight whereby the ascending side in every one of these revolutions does exceed the other; And though this may be effected by making the water-wheels' larger, yet then the motion will be so slow, that the Screw will not be able to supply the outward streams.

There is another contrivance to this purpose mentioned by *Kircher de Magnete, l. 2. p. 4.* depending upon the heat of the Sun, and the force of winds, but it is liable to such abundance of exceptions, that it is scarce worth the mentioning, and does by no means deserve the confidence of any ingenious artist.

Thus have I briefly explained the probabilities and defects of those subtle contrivances, whereby the making of a perpetuall motion hath been attempted. I would be loath to discourage the enquiry of any ingenious artificer,



artificer, by denying the possibility of effecting it with any of these Mechanical helps; But yet (I conceive) if those principles which concern the slownesse of the power in comparison to the greatnesse of the weight, were rightly understood, and thoroughly considered, they would make this experiment to seem (if not altogether impossible, yet) much more difficult then otherwise perhaps it will appear. However, the inquiring after it, cannot but deserve our endeavours, as being one of the most noble amongst all these Mechanical subtilties. And (as it is in the fable of him who dugge the Vineyard, for a hid treasure, though he did not finde the money, yet he thereby made the ground more fruitfull, so) though we do not attain to the effecting of this particular, yet our searching after it may discover so many other excellent subtilties, as shall abundantly recompense the labour of our enquiry.

And then besides, it may be another encouragement to consider the

Treated  
of before,  
L. I. C.

διδάσκει καὶ  
 οὐνοῖς  
 σελήνῃ &c.  
 Plutarch.  
 Marcell.  
 Joan. Tzet-  
 zes, Chil.  
 1 Hist. 35.  
 Valer.  
 Maxim. l.  
 8. c. 7.

pleasure of such speculations, which doe ravish and sublime the thoughts with more clear angelicall contentments. *Archimedes* was generally so taken up in the delight of these Mathematicall studies of this familiar *Siren*, (as *Plutarch* stiles them) that he forgot both his meat and drink, and other necessities of nature ; nay, that he neglected the saving of his life, when that rude soldier in the pride and haſt of victory, would not give him leiſure to finiſh his demonſtration, What a raviſhment was that, when having found out the way to meaſure *Hiero's* Crown, he leaped out of the Bath, and (as if he were ſuddenly poſſeſt) ran naked up and down crying *εὐρηκα εὐρηκα !* It is ſtoried of *Thales* that in his joy and gratitude for one of theſe Mathematical invenventions, he went preſently to the Temple, and there offered up a ſolemn ſacrifice. And *Pythagoras* upon the like occaſion is related to have ſacrificed a hundred oxen. The juſtice of providence ha-  
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ving so contrived it, that the pleasure which there is in the successe of such inventions, should be proportioned to the great difficulty and labour of their inquiry.

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**WILKINS, JOHN** (1614-1672), bishop of Chester; B.A. Magdalen Hall, Oxford, 1631; M.A., 1634; vicar of Fawsley, 1637; private chaplain to prince palatine, Charles Lewis, nephew of Charles I; adhered to parliamentary side in civil war and took covenant: B.D., 1648; warden of Wadham College, Oxford, 1648-59; D.D., 1649; centre of group of men who formed Royal Society, 1662, and first secretary; master of Trinity College, Cambridge, 1659; incorporated D.D. Cambridge, 1659; deprived of mastership at Restoration; prebendary of York, 1660; vicar of St. Lawrence Jewry, London, 1652; dean of Ripon, 1663; prebendary and precentor of Exeter, 1667; prebendary of St. Paul's Cathedral, 1668; bishop of Chester, 1668; published 'The Discovery of a World in the Moone,' 1638, 'A Discourse tending to prove that 'tis probable our Earth is one of the Planets,' 1640, 'Mathematical Magick,' 1648, and 'An Essay towards a real Character and a Philosophical Language,' 1668 (suggested by the 'Ars Signorum' of George Dalgarno [q. v.]), and other works.

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